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ORIGINAL ARTICLES.

I.—On some New Zealand Graptolites.

By Ethel M. R. Shakespear, D.Sc.

THE New Zealand graptolites which are dealt with in this paper were collected by Mr. E. Douglas Isaacson, mining engineer, New Zealand, for the British Museum (Natural History), South Kensington. Dr. A. Smith Woodward, F.R.S., very kindly gave me the opportunity of examining this interesting collection, which was sent to me in the Autumn of 1907. Shortly after its receipt Dr. Woodward forwarded me a copy of the New Zealand Geological Survey publication entitled "The Geology of the Parapara Subdivision, Karamea, Nelson," by James Mackintosh Bell, Director, 1907, which contains brief descriptions and figures of graptolites collected from the same locality as that from which Mr. Isaacson collected his specimens. Since, however, the records of graptolites from New Zealand are very limited in number, and since Mr. Isaacson's collection contains a greater variety of forms than that of any previous observer, it seems advisable to publish the identifications that I have found it possible to make from an examination of his collection.

In addition to the actual specimens, Mr. Isaacson's maps and notes were placed at my disposal, and from these I have obtained the following facts concerning the occurrence of the graptolite-bearing rocks.

The locality from which Mr. Isaacson obtained his specimens is that of Slaty Creek, not far from Aorangi mine, in the Aorere district of the Karamea division. It is about nine miles south of the southern end of the Wanganui Inlet, which is situated at the extreme north-western corner of the Middle Island of New Zealand. The floor of the country consists for the most part of a series of unfossiliferous blue slates (Aorere Series), but interbedded with these is a "highly carbonised band," only a "few inches in thickness." "The auriferous reefs of the locality are only found in intimate association with this graphitic (carbonised) slate. The reef itself has a thin coating of graphite, and between the graphite and the slate is a block pug seam; while the slate itself is generally in a very crushed condition." The graptolites were "obtained almost anywhere on the line of the reef,

and both on the footwall and hanging wall of the reef itself in the workings." They are confined to the fine textured slates, the coarser ones being quite unfossiliferous.

According to Mr. Bell (loc. cit., p. 34), the Aorere rocks in this district are as a whole "folded into a great synclinorium," but the "plication of the strata has been enormous, the rocks having been folded into a series of very closely compressed troughs and arches, which have a general trend of about north-north-west, with many variations from regularity." At the locality where the graptolites were obtained the dip of the beds is about 30° to the west.

Mr. Isaacson states that all the graptolites in his collection came from the one band. It is, however, possible to distinguish two main rock types, namely: (*a*) a somewhat coarse shale with an irregular fracture, and (*b*) a fine, smooth, well-laminated shale.

In the first of these (*a*) I have identified the following species:—

Bryograptus Lapworthi, Ruedemann.
Dichograptus octobrachiatus, Hall.
Didymograptus extensus, Hall.
D. gibberulus, Nicholson (*caducus*, Salter).
D. nitidus, Hall.
Diplograptus sp. (?).
Goniograptus perflexilis, Ruedemann.
Loganograptus Logani, Hall.
Phyllograptus Anna, Hall.
Ph. ilicifolius, Hall.
Tetragraptus Amii, Elles & Wood.

In the second (*b*) I have recognised—

Bryograptus Lapworthi, Ruedemann.
Didymograptus affinis (?), Nicholson.
D. nanus, Lapworth.
D. similis (?), Ruedemann.
Goniograptus geometricus, Ruedemann.
Phyllograptus Anna, Hall.
Phyllograptus typus, Hall.
Strophograptus trichomanes (?), Ruedemann.
Tetragraptus Bigsbyi, Hall (*similis*, Hall).
T. cf. *pendens*, Elles.
T. quadribrachiatus, Hall.

Intermediate in character between these two extreme rock types there are a few slabs of shale, readily distinguishable by the mode of preservation of their contained graptolites, which have yielded *Didymog. nanus*, *Phyllog. angustifolius*, *Phyllog. Anna*, and *Tetrag. Bigsbyi*. These, however, may be grouped with (*b*).

Thus the two types of rock are distinct, not only lithologically, but also palæontologically, and in this one collection there are represented two different graptolitic zones or sub-zones. Either, then, these two graptolitic zones occur within the one carbonaceous band of a few inches in thickness, or there is more than one graptolitiferous band in the neighbourhood of the reef. Without further information it is impossible to decide between these two suggested alternatives, but the evidence brought forward by Mr. Isaacson and Mr. Bell as to the movement that the rocks have undergone, and the occurrence of the graptolites both on the walls of the reef itself and in its neighbourhood, seems to be in favour of the possibility of there being two distinct graptolitiferous bands present.

The fauna of the band (*a*) is characterised by the abundance of the species *Didymog. gibberulus*. It is undoubtedly the same fauna as that described by Mr. Bell; and if we except his identification of *Rastrites* (which may be a fragment of *Goniograptus perflexilis*) the assemblage of graptolites is that which one might expect. The forms which he doubtfully refers to *Climacograptus* and *Diplograptus* may belong to one and the same species; and from an examination of the one or two

specimens which occur in the present collection it appears that they belong to a primitive type of *Diplograptus* allied to *Diplograptus inutilis*, Hall. It may be a new species.

The fauna represented in the second band (*b*) seems not to have been detected by Mr. Bell and his assistants, though its previous recognition in New Zealand is evident from the figures of graptolites given by the late Sir James Hector (Handbook of New Zealand, 1886, p. 82). In this band the most characteristic species are *Didymograptus nanus*, and *Tetragraptus Bigsbyi*, while *Didymog. gibberulus* appears to be entirely absent.

Below is a table showing the distribution of these New Zealand graptolites in America and Great Britain; and an examination of this brings out clearly the great similarity between these two New Zealand faunas or sub-faunas and those of corresponding age in the Northern Hemisphere.

	Slaty Creek, New Zealand.		Deep Kill, State of New York.				Wales.			Lake District.	
	Band (*a*).	Band (*b*).	Zone of *Tetragraptus*. Bed 1.	Zone of *Tetragraptus*. Bed 2.	Zone of *Didymog. bifidus*. Bed 3.	Zone of *Didymog. bifidus*. Bed 5.	Zone of *Didymog. extensus*.	Zone of *Didymog. hirundo*.	Zone of *Didymog. bifidus*.	Upper *Tetragraptus* Beds.	Ellergill Beds.
Bryog. Lapworthi ...	?	r	c	cc	...	...	...	...	...	...	...
Diclog. octobrachiatus ...	lc	...	rr	cc	r	...	...	...	...	l	...
Didymog. extensus ...	c	...	...	cc	...	...	l	...	...	l	...
D. gibberulus	cc	...	...	...	...	?	l	...	...	l	...
D. nitidus	r	...	c	c	...	...	l	l	...	l	...
Diplograptus sp.	r	...	...	...	...	...	...	...	...	...	...
Goniog. perflexilis ...	lc	...	...	cc	r	...	...	...	...	...	...
Loganog. Logani	c	...	...	cc ?	...	...	...	...	...	l	...
Phyllog. Anna	r	lc	...	r	cc	c	...	...	...	l	...
Ph. ilicifolius	r	...	r	cc	...	r	...	...	...	...	...
Tetrag. Aqui	r	...	...	c	...	...	l	...	...	l	...
Didymog. affinis ? ...	...	r	...	...	...	...	...	...	...	l	l
D. nanus	...	cc	...	...	...	x	...	r	l	...	l
D. similis ?	...	lc	...	...	r	c	...	...	...	...	...
Goniog. geometricus ...	...	c	...	r	cc	...	...	...	?	...	...
Phyllog. angustifolius ...	...	lc	rr	r	c	...	...	...	...	l	l
Ph. typus	...	r	...	...	c	cc	...	...	...	l	...
Strophog. trichomanes ? ...	...	r	...	...	...	...	...	...	...	...	...
Tetrag. Bigsbyi	...	cc	...	cc	c	...	...	...	l	l	l
T. cf. pendens	...	lc	...	...	r	...	...	...	...	...	l
T. quadribrachiatus ...	...	rr	...	c	r	...	l	...	...	...	l

cc = very common; c = common; lc = fairly common; r = rare; rr = very rare.

Especially close is the comparison between the two New Zealand faunas and those of the beds 2 and 3 of Ruedemann in his Deep Kill section (Graptolites of New York, part 1, 1904, pp. 504–507). Some of the new species described by Ruedemann in this great work, which have not hitherto been recognised in other parts of the world, are to be found in Mr. Isaacson's collection. The fauna of the band (*a*) corresponds to that of bed 2, and the fauna of (*b*) to that of bed 3, and this fact gives additional support to the assumption that in the Aorere Series of New Zealand two graptolitiferous zones are represented.

With Great Britain the comparison, though close, is not so striking. This is mainly due to the fact that in Britain the rocks at this horizon are not so rich in species as they are in America. So far, however, as the range of the species which are common to both Great Britain and New Zealand is concerned, it is clear that the fauna (*a*) corresponds to that of the zone of *Didymograptus extensus*, and the fauna of (*b*) to that of the zone of *Didymograptus hirundo*. In Wales the *Didymograptus hirundo* zone is extremely poor in species, and the zone fossil has not yet been recognised from New Zealand. In Britain *Didymograptus nanus* makes its first appearance in this zone, though it is very rare; probably, therefore, the fauna of (*a*) corresponds to that of the highest beds of the *D. hirundo* zone and to that of the base of the overlying zone of *D. bifidus*.

In the Lake District the New Zealand faunas find their representatives in the Middle Skiddaw Slates, and probably also in the lowest beds of the Ellergills.

Mr. Isaacson's present discovery shows indisputably that the association of forms in the part of New Zealand which he has investigated is practically the same as that in the Northern Hemisphere; and it may be anticipated that further work will result in proving that the zonal succession of graptolites so well established in the Northern Hemisphere prevails in New Zealand also.

II.—Marine Beds in the Yorkshire Coal-measures above the Barnsley Coal.

By H. Culpin.

In Green's "Geology of the Yorkshire Coalfield" (Mem. Geol. Surv., 1878, p. 471) reference was made to the occurrence below the Ackworth rock of a band of black shale, which it was said "contains *Aviculopecten* in plenty, and shows that incursions of the sea continued to occur even up to these comparatively late portions of the Coal Measure period."

A recent sinking for coal at Brodsworth, about four miles north-west of Doncaster, gave an opportunity, which the Colliery Management kindly facilitated, for a search for the above and other marine beds above the Barnsley Coal, with the result that four such beds have been noted there, one of which has markedly distinctive lithological and faunal characters.

Taking the beds in descending order, the *first* was found in some 32 feet of 'blue bind,' the base of which was 106½ feet below the

Ackworth rock, 17 feet above the Shafton Coal, and 1,130 feet above the Barnsley Coal. This bed is probably the one mentioned by Green. At Brodsworth its examination yielded numerous fragments of Goniatites, including a curiously preserved *Gluphioceras* sp., showing the suture-lines. The other mollusca were *Lingula mytiloides* (very abundant), *Pterinopecten papyraceus* (abundant), *Posidoniella laevis*, and *Nuculana acuta*. Of fish-remains only *Megalichthys* was determinable. There were occasional traces of plants, including *Calamites* sp. and *Neuropteris heterophylla*, Brongn.

The base of the *second* bed, which was apparently about 15 feet thick, was 219 feet above the Melton Field Coal and 705 feet above the Barnsley Coal. The top of it consisted of blue fucoid-marked shales with a soapy feel. Then came similar shales crowded with *Lingula*, followed by greyish-blue harder shales with abundant *Pterinopecten*, *Goniatites*, etc. The base was a very hard greyish-blue limestone 'cank,' which broke the drills. The lithological characters of the bed were remarkably different, both to the eye and the touch, from the ordinary measures, and should enable the mining expert to readily distinguish and use it as a datum-line in any future boring or sinking. The following is the list of fossils found in it:—

BRACHIOPODA.

Chonetes laguessiana, mut. *θ*.
Orbiculoidea nitida.
Lingula mytiloides (very abundant).

LAMELLIBRANCHIATA.

Syncyclonema carboniferum, Hind (abundant).
Pterinopecten papyraceus, Sow. (very abundant).
Posidoniella sulcata, Hind.
Myalina compressa, Hind.
Nucula aequalis, Sow.
Nuculana acuta, Sow.
Ctenodonta lacvirostris, Portl. (very abundant).

GASTEROPODA.

Euphemus sp. (probably new).

CEPHALOPODA.

Pleuronautilus costatus, Hind.
Glaphioceras microstoma, Phill.
Glyphioceras reticulatum (?), Phill.
Dimorphoceras Gilbertsoni, Phill.
Orthoceras acicalare, Brown.
Orthoceras Steinhaueri, Sow.

PISCES.

Acanthodes.
Elonichthys Egertoni.
Megalichthys Hibberti.
Rhizodopsis sauroides.

PLANTÆ.

Lepidodendron sp.
Neuropteris heterophylla, Brongn.
Neuropteris cf. *rarinervis*, Bunb.

The base of the *third* bed was 100 feet below the Melton Field Coal and 382 feet above the Barnsley Coal. It yielded *Pterinopecten papyraceus* and numerous specimens of *Lingula mytiloides*, which in some parts of the bed were very small, and in other parts exceptionally large. Fish fragments were plentiful, including—

Acanthodes Wardi.
Pleuroplax Ramkinei.
Celacanthus elegans.
Rhadinichthys monensis.
Rhizodopsis sauroides.

The *fourth* bed, which had a hard 'cank' at its base, was 111 feet above the Barnsley Coal. It yielded only *Lingula mytiloides*; and a fish-scale which was probably *Rhizodopsis sauroides*. In this case, *Spirorbis*, *Carbonicola* var. *aquilina*, and *Naiadites modiolaris* occurred in close proximity to the Lingula material.

Thanks are due to Dr. Walcot Gibson for encouragement and assistance in the work; and to Dr. Wheelton Hind, Dr. A. Smith Woodward, and Mr. R. Kidston for examining and naming the mollusca, the fish, and the plant-remains.

III.—The New Red (Permian) Gravels of the Tiverton District.

By Edgar C. Martin, B.Sc., A.I.C.

Introduction.

AMONGST the Lower New Red deposits of the Tiverton area are loose rubbly aggregations of angular and subangular fragments of grit and sandstone of all sizes in a loose earthy or sandy matrix.[1] These deposits, which seem best described by the term gravel, rest unconformably on the grits and shales of the Culm-measures, from which they appear to have been largely derived. In the deeper areas of deposit, further from the Culm margin, they pass into finer breccias and sand.[2] These gravels were formerly regarded as superficial deposits, and it has been suggested that they may be Boulder-clays.[3] Detailed mapping, however, proved their distinct connection with the Lower New Red Sandstones and breccias, and they have been found in places, as at Washfield and Silverton, underlying the trap, which corresponds to the German Permian Melaphyre (Middle Sötern); hence they are now regarded as deposits of Permian age.

About forty years ago Mr. J. T. Underhill found amongst the fragments in the Exeter Hill gravel-pit, Tiverton, some with an assemblage of Upper Devonian fossils. These were placed in the Exeter Museum, where, some time later, they attracted the attention of the Rev. W. Downes. On the occasion of the construction of the Exe Valley Railway he examined the cuttings between Tiverton and Bolham and noticed fragments of grit with *Spirifer Verneuili*, Murch., *Strophalosia productoides*, Murch., sp., and other Pilton fossils.[4] These fragments were associated with pieces of trap, and having regard to the proximity of the Washfield trap, Downes was led to the conclusion that the Devonian fragments were ejected during the volcanic outbursts.

The present investigation was undertaken at the suggestion of Mr. Underhill with the object of examining the whole area where the gravels occur in order to find how far Devonian fragments could be traced, and in the hope of throwing light on the source from which these fragments have been derived.

In the following account the area has been divided into districts, in order that the places mentioned may be more easily found on the map.

1. District north-west of Tiverton.
2. District north-east of Tiverton.
3. Butterleigh District.
4. Silverton and Bradninch District.
5. Thorverton District.

The first three districts are included in Sheet 310 of the Ordnance Survey (1 inch scale), and the last two districts in Sheet 325 of the Geological Survey.

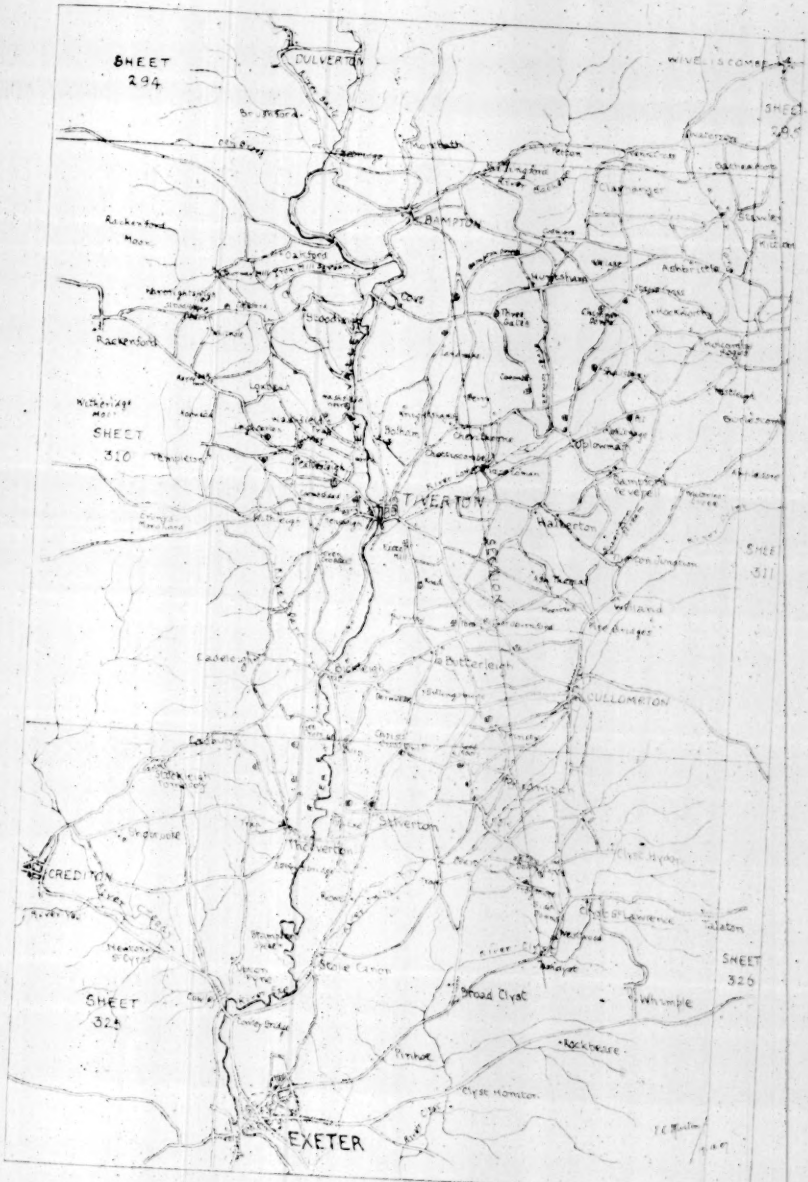
[1] Quart. Journ. Geol. Soc., 1876, pp. 387–389.

[2] Memoirs of the Geol. Survey, Exeter District, 1902, pp. 29, 33.

[3] Geol. Mag., 1872, p. 571: "Bould r-clay in Devonshire."

[4] Rev. W. Downes, B.A., F.G.S., "On the occurrence of Upper Devonian Fossils in the component fragments of the Trias near Tiverton": Transactions of the Devonshire Association, 1881.

MAP OF THE TIVERTON DISTRICT.



Places where Upper Devonian fragments have been found in the New Red Gravels are marked thus ⊕. Scale, 4 miles to an inch.

1. District North-West of Tiverton.

The valley between Washfield and Calverleigh is filled with the gravels as far west as Holmead. Two outlying patches of gravel occur north-west of Stoodleigh.

In a section about a quarter of a mile north-west of Washfield Church, on the Stoodleigh Road, the gravels are seen underlying the trap. Fragments of soft red sandstone containing crinoid joints, *Spirifer Verneuili*, Murch., and *Rhynchonella Partridgiæ*, Whidborne,[1] were found about three feet below the trap. Fossiliferous fragments were also detected in the gravel-pits on Hensleigh Hill and behind the Roman Catholic Chapel, Tiverton, and in the road section at Leigh Barton, near Loxbear.

In a small gravel-pit on the Templeton Road, three-quarters of a mile west of Calverleigh, at an elevation of 800 feet, the following fossils were found in pieces of dark red sandstone and grit:—

Phacops latifrons, Bronn (two heads and one tail).
Spirifer Verneuili, Murch.
Rhynchonella Partridgiæ, Whidb.
Orthis interlineata, Sow.
Tentaculites conicus, F. A. Römer.
Strophalosia productoides, Murch., sp.
Crinoid joints.

The gravels are well exposed at Washfield Weir, by the Exe, and contain fossiliferous fragments. In the pebble bed in the Exe below the weir (the pebbles composing which seem to have been washed out of the cliff or gravel above the weir) fragments of hard grit with the following fossils were found:—

Spirifer Verneuili, Murch.
S. Urii, Fleming.
Pentamerus pentagonus, Sow.
Rhynchonella Partridgiæ, Whidb.
Orthis interlineata, Sow.
? *Cenodonta trata*, Phil., sp.
? *Sanguinolites minus*, Whidb.
Adelocrinus hystrix, Phil.

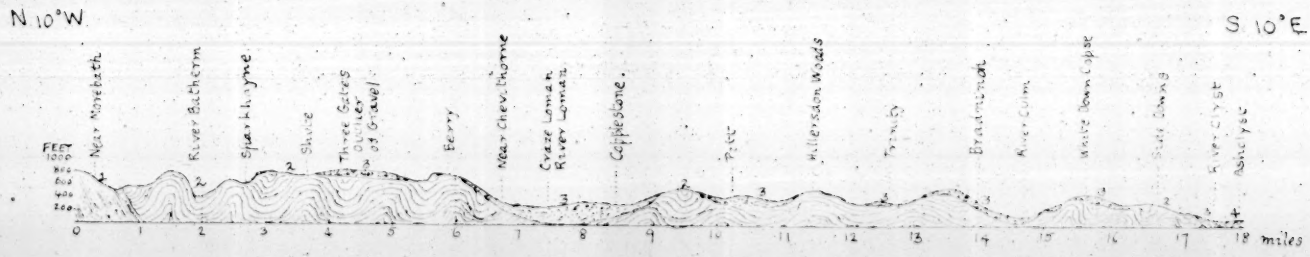
The Stoodleigh Outliers.

Two outliers of the New Red gravels occur in Stoodleigh parish. The first caps the hill north of Stoodleigh village, and can be examined in a large gravel-pit about half a mile north-west of Stoodleigh Church, 936 feet above sea-level. The deposit in this pit is very coarse, and no fossiliferous pieces were detected there. The second outlier covers a much larger area in the north-west part of Stoodleigh parish. It is interesting as being the last as well as the highest patch of the gravels in this direction. It can be examined in a gravel-pit at Stoodleigh Beacon, 980 feet above sea-level. Fragments of yellowish-red grit found in this pit contained *Spirifer Verneuili*, Murch., *Fenestella plebeia*, M'Coy, *Loxonema* (?) sp., and Crinoids.

In the lane east of Stoodleigh Beacon trap occurs, and a fragment containing *Naticopsis Hallii*, Whidb., was found.

[1] Phillips, in his "Palæozoic Fossils of Devon, Cornwall, and West Somerset," refers this very common 'Rhynchonella' to his Carboniferous species *Rhynchonella pleurodon*. Whidborne ("Devonian Fauna of the South of England," vol. iii) thinks that the Devonian species is specifically distinct, and has named it *Rhynchonella (Camarotæchia) Partridgiæ*, Whidb.

SECTION FROM MOREBATH, NEAR DULVERTON, TO THE RIVER CLYST.



Permian	...	...	4. Lower Marls.
			3. Gravels with occasional breccias and sandstones.
Carboniferous	...	...	2. Culm Grits and shales.
Devonian	...	...	1. Pilton Beds.

In the lane section west of Warbrightsleigh Barton pieces of soft reddish micaceous sandstone were found with *Rhynchonella Partridgiæ*, Whidb., *Fenestella plebeia*, M'Coy, and Crinoids. This section is very close to the outcrop of the Culm-measures, which are quarried in a field to the north. The deposit at Warbrightsleigh is much finer and more consolidated than that occurring at Stoodleigh Beacon.

2. District North-East of Tiverton.

In the gravel-pit at Bolham about 30 feet of a very coarse earthy gravel are exposed. Pieces of dark red 'rotten' sandstone containing *Orthis interlineata*, Sow., and other fossils are common.

At Uplowman the gravels are exposed in a road section north of the Church. A piece of soft red sandstone found here contained *Aviculopecten transversus*, Sow., sp. Another piece was crowded with small Gasteropods and other fossils, including the following species:—

Euomphalus vernis, Whidb.	*Aviculopecten nexilis*, Sow., sp.
Bellerophon subglobatus, M'Coy.	? *Spirifera cristata*, var. *octoplicata*, Sow.
? *Macrochilina* sp.	*Spirifer Urii*, Flem.
Tentaculites tentaculare, Phil., sp.	Crinoid stems.

Similar fragments with the same species were found at Coombe, near Uplowman, and at Pit, north-east of Sampford Peverell.

Three Gates Outlier.

A large outlying patch of gravel caps the hill between Huntsham and Cove. It can be examined in three gravel-pits on the Upper Tiverton—Bampton Road, north of Landrake. In two of these pits fossiliferous fragments were found. In the most northerly pit a piece of crinoidal sandstone measuring $6 \times 2\frac{1}{2} \times 3\frac{1}{2}$ inches was noticed.

Further east the gravels are exposed in a pit by Three Gates Farm. In this pit fossiliferous pieces of grit and sandstone are abundant, and contain the following species:—

Phacops latifrons, Bronn.	*Spirifer Verneuili*, Murch.
Fenestella plebeia, M'Coy.	*S. Urii*, Flem.
Pentremites pyramidalis, Phil., sp.	*Rhynchonella Partridgiæ*, Whidb.
Scaniania oblonga, Sow., sp.	Crinoid stems.

Chimney Down Outlier.

This is the last patch of gravel to the north-east, and the fossiliferous fragments are much more plentiful here than elsewhere. This fact is significant, since Chimney Down is only about two miles distant from the outcrop of the Pilton Beds, where the same species of fossils can be found *in situ*.

The gravel-pit on Chimney Down, 878 feet above sea-level, exhibits a very coarse unstratified gravel composed of angular and subangular fragments of grit and sandstone of all sizes up to over two feet in length in a red earthy matrix. The surfaces of the pebbles are very often smooth and somewhat polished. One large fragment of grit ($23 \times 18 \times 15$ inches) contained a fossiliferous layer two inches thick.

Pieces of soft red sandstone, crowded with fossils, are very common. A single piece, about two feet long, yielded the following species:—

Phacops latifrons, Brönn (at least twenty heads, but only one tail).
Bellerophon subglobatus, M'Coy (very common).
Euomphalus rotuus, Whidb. (very common).
Pleurotomaria aspera, Sow.
Tentaculites tentaculare, Phil., sp.
? *Macrochilina turbinea*, Whidb.
? *Naticopsis Hallii*, Whidb.
? *Murchisonia* sp.
Spirifer Verneuili, Murch. (very common).
Spirifer Urii, Flem.
Rhynchonella Pactridgiæ, Whidb. (very common).
Productus praelongus, Sow. (very common).
Strophalosia productoides, Murch., sp.
Semimicia oblonga, Sow., sp.
Athyris (Cleothyris) Roissii, Leveillé.
Orthoceras Barrandeæ, Whidb.
Aviculopecten transversus, Sow., sp.
Several undetermined Lamellibranchs.
Crinoid joints.

Another piece of sandstone was crowded with casts of *Cucullæa* similar to those occurring in the Marwood Beds of North Devon.

Spalsbury Outlier.

A small patch of gravel between Chimney Down and Uplowman is exposed in a gravel-pit near Spalsbury. Crinoidal fragments of grit were found here.

3. Butterleigh District.

This includes the district south-east of Tiverton embraced in the Ordnance Survey one-inch map, Sheet 310.

The Exeter Hill gravel-pit, near Tiverton, is mentioned in a letter by H. B. Woodward, F.G.S., to the Geol. Mag. (1872, p. 574), calling attention to the resemblance between the New Red deposit exposed there and the Boulder-clays. Here, as elsewhere, fragments with Upper Devonian fossils occur. One piece of grit contained numerous casts of the small Gasteropod *Bellerophon subglobatus*, M'Coy. Another contained a Lamellibranch similar to *Pleuronectites Piltonensis*, Whidb.

Similar gravel-pits occur at Road Farm and south of Butterleigh, and in both fossiliferous fragments have been detected. They have also been found in the road sections near Ford, and on the Tiverton road 1½ miles north-west of Cullompton. On the common above Trinity a piece of grit with *Strophalosia productoides*, Murch., sp., was found.

Between Tiverton and Butterleigh the fragments of grit are gathered off the fields and used for road-mending. In these fragments the following species have been found:—

Phacops latifrons, Brönn.
Spirifer Verneuili, Murch.
S. Urii, Flem.
Orthis interlineata, Sow.
Rhynchonella Pactridgiæ, Whidb.
Strophalosia productoides, Murch., sp.
Fenestella plebeia, M'Coy.
? *Fistulipora* sp.
? *Cteiodonta laxata*, Phil., sp.
Crinoid joints.

4. Silverton and Bradninch District.

A full account of the geology of this district will be found in the Memoirs of the Geological Survey, Exeter district, by W. A. E. Ussher. In the Silverton and Bradninch district the

gravels occupy the higher grounds (400 to 850 feet) and are replaced by breccias in the lower grounds. Fossiliferous fragments occur, but are not so common as further north. They have been detected at Christ Cross, near Silverton (847 feet), and in the lane sections north-west of Bradninch. The species found included :—

Spirifer Verneuili, Murch. *Tentaculites conicus*, F. A. Römer.
Rhynchonella Partridgiæ, Whidb. Crinoid remains.

A fragment of grit with *Spirifer Verneuili* was found in the section by the Tiverton-Exeter Road, south of Jenny's Portion.

The last patch of gravel mantles the slopes of the large Culm inlier at White Down Copse, in the parish of Broad Clyst; and here, 15 miles in a straight line from the outcrop of the Pilton Beds, fragments of grit with Pilton fossils occur. They were found in the lane section east of Frogmore, and in another section still further to the east. The species found included *Rhynchonella Partridgiæ*, Whidb., *Ctenodonta lirata*, Phil., sp., and Crinoids.

5. Thorverton District.

The following note appears in the Geological Memoir of the Exeter District (p. 7) :—"South of Cadbury, between the streamlets near Kidlake (West Bowley on the old series map), amongst numerous fragments of brown grit scattered over the surface one containing casts resembling *Strophomena* was picked up. The stones, although unworn, may be mixed with débris resulting from the denudation of lower New Red rocks."

Fragments with Upper Devonian fossils are fairly common in the road sections and ploughed fields north of Thorverton. They contain the usual fossils, *Spirifer Verneuili*, Murch., and *Rhynchonella Partridgiæ*, Whidb., being the most common. Further west, between Thorverton and Crediton, the gravels are replaced by breccias composed largely of trap. No fossiliferous pieces have been detected in this direction.

Summary and Conclusions.

The New Red gravels of the Tiverton type extend from Warbrightsleigh and Chimney Down on the north to Thorverton and White Down Copse on the south. Further south they are replaced by breccias and sandstones or covered by the higher beds of the New Red series. Throughout the whole of this area of nearly 100 square miles the gravels contain fragments of sandstone and grit with Upper Devonian fossils. These Devonian fragments are most common in the north-east of the district, and are comparatively rare further south. They are found at the entrance of the Crediton valley, but do not appear to be present further west.

All the fossils that have been identified are known to occur in the Pilton and Marwood Beds of North Devon. The only Trilobite found (*Phacops latifrons*, Bronn) is practically the only Trilobite occurring in the Pilton Beds, where it is very common. *Spirifer Verneuili*, Murch., *Spirifer Urii*, Flem., *Rhynchonella Camaratæchia Partridgiæ*, Whidb., and *Productus praelongus*, Sowerby, are the commonest Brachiopods both in the gravels and in the Pilton Beds. The little

Gasteropod *Exomphalus vermis*, Whidb., is also common in the gravels and Pilton Beds. *Bellerophon subglobatus*, M'Coy, is a characteristic fossil in the Marwood Beds of the Barnstaple district; it is also common in the grits that occur further east near Wiveliscombe, and in the grit fragments found in the gravels.

At Chimney Down, in the north-east of the district, fossiliferous fragments of Upper Devonian sandstone and grit are extremely common, whilst trap fragments appear to be absent. This fact, as well as the wide distribution of the fossiliferous fragments, completely disposes of the Rev. W. Downes' theory of volcanic ejection. The facts tend, rather, to prove a drift from the north-east during the period of deposition of the gravels. The grit and sandstone matrices suggest a derivation from the Wiveliscombe end of the Pilton Beds rather than from the more slaty beds found further west. The Devonian fragments in the gravels may even have been derived from a still more easterly extension of the Pilton Beds, now buried under Triassic deposits.

The angular and subangular nature of the fragments composing the gravels, as well as the non-separation of coarse and fine material, gives the impression that the component fragments have not travelled far, and yet at White Down Copse they are found at least 15 miles from the outcrop of the Pilton Beds. The fossiliferous pebbles found at White Down Copse were all subangular. These New Red deposits certainly bear a considerable resemblance to the Boulder-clays, but in the absence of striated pebbles (and none have yet been found) the theory that they are glacial deposits is hardly admissible.

Mr. Ussher regards the gravels as the result of torrential action periodically operating on the margin of an area of depression attended by periodic dessication and wind-drift. This supposition is in accordance with our present views of the climate of England in Permian and Triassic times, and would explain the coarse unstratified nature of the deposits. The derivation from the north-east is natural on this supposition, but difficult to explain on any other theory such as that of marine agency. For the New Red rocks are overlapped on the margin of the Middle Devonian rocks near Williton, and thence to Porlock Triassic rocks alone represent the series. Hence, on the marine derivation theory a drift from the north is highly improbable, and we would have to suppose drift from the east where the extension of Devonian rocks may be expected to occur beneath the New Red rocks. The theory of torrential derivation from the north-east is therefore most probable and is consistent with the appearance of the deposits. These torrents carried the fragments as far as the entrance of the Crediton valley, where they were met by other torrents bringing down fragments of trap from the upper parts of this valley. The fact that the Devonian fragments are apparently absent to the west of Thorverton and that the gravels are replaced by a breccia composed largely of trap is thus explained.

The author's best thanks are due to Mr. J. T. Underhill for proposing the investigation and to Mr. W. A. E. Ussher for some of the above suggestions.

IV.—A Revision of some Carboniferous Corals.[1]

By R. G. Carruthers, of the Geological Survey.

(PLATE VI.)

(*Concluded from the February Number, page 74.*)

Genus CANINIA.

1840. *Caninia*, Michelin.
1850. *Cyathopsis*, d'Orbigny.
1906. *Amplexi-Zaphrentis*, Vaughan.

(For full synonymy of the type species see below.)

Corallum simple, turbinate and conical, often slender and cylindrical for a great part of its length.

Major septa well developed and meeting in the centre in the lower, conical part of the coral, but in the cylindrical portions usually becoming amplexoid in character.

Minor septa of various lengths in different species.

Cardinal fossula variable in extent, characteristically limited by tabulæ only, at the inner end, and with the flanking septa loose or disconnected.

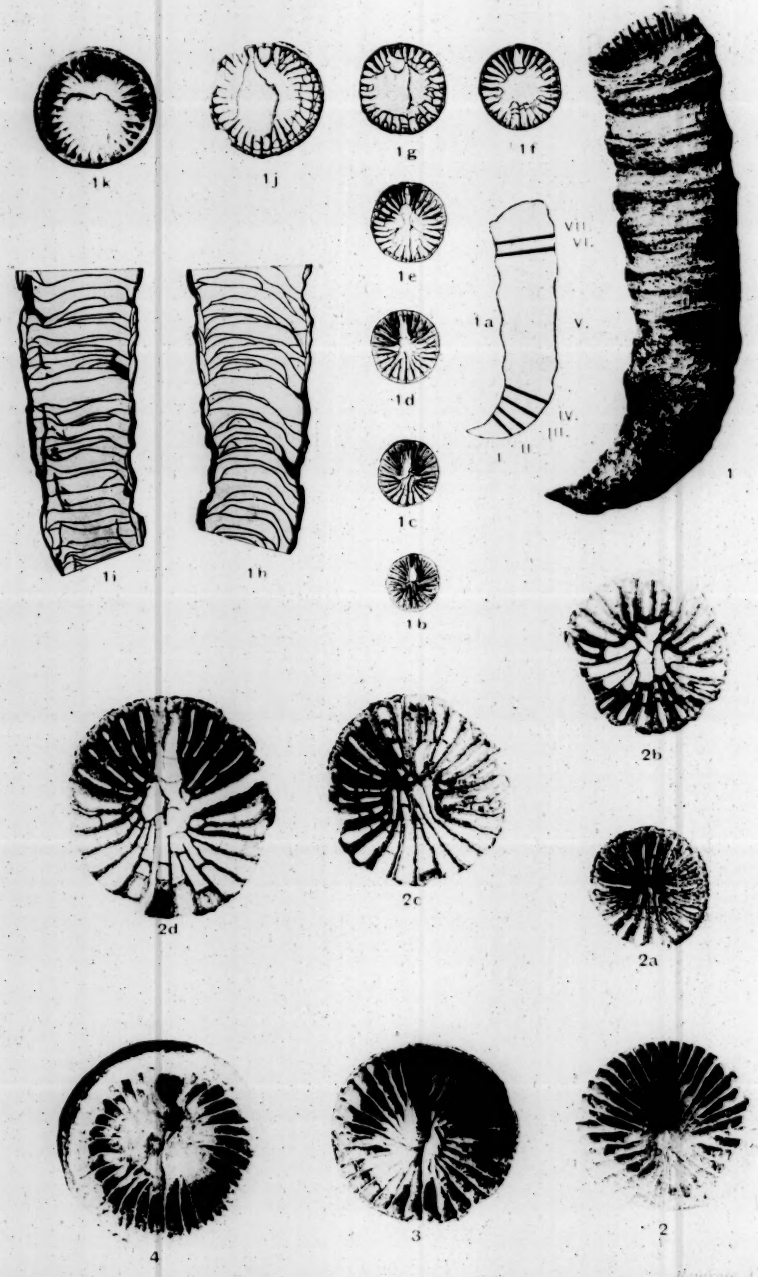
Tabulæ well developed, but variable in regularity; they may be highly arched and vesicular. A marginal ring of more or less vertical *dissepiments*, usually thin and delicate, intervenes in the mature stages of growth between the tabulæ and the wall.

The foregoing re-definition of the genus *Caninia* is founded on an examination of *C. cornucopiæ*, and of allied forms found in the English Visean, most of which are at present undescribed. Reasons for regarding this species as the genotype will be adduced in the sequel, when discussing that coral. Previous authors seem to have regarded the genus as typified by *Caninia gigantea*, Mich. (equivalent, according to McCoy, to *Siphonophyllia cylindrica*, Scouler). The mistake is easily explained, and it is somewhat surprising that it appears to have been overlooked for so long a time.

The genus was at first defined by Michelin without mention of species, while the first species given (*C. cornucopiæ*, q.v.) was referred to by name only, without any diagnosis; it was not until Michelin published his important "Iconographie Zoophytologique" that any description of illustrative species appeared. But Michelin, in this publication, adopted a geographical and not a zoological arrangement for his data, describing the coral faunas of various districts without any regular zoological order; the work also appeared in parts, whose publication was spread over several years (1840 to 1847).

The genus *Caninia* is first mentioned in the "Iconographie", p. 81 without diagnosis, and a new species, *C. gigantea*, figured and described. Before any further parts containing a reference to the genus were

[1] Communicated by permission of the Director of the Geological Survey of Great Britain.



Cantria Cornucopiæ, Mich.

CARBONIFEROUS LIMESTONE. TOURNAI.

issued, Lonsdale[1] adopted Michelin's genus, taking as his example the only form, *C. gigantea*, yet described; it was not till several years later, when dealing with the fauna of Tournai, that a description of *C. cornucopiæ* appeared.

Lonsdale's example was followed by McCoy and other later writers, and amongst these Stuckenberg should be mentioned.[2] Some observations on *Caninia* were made in 1897 by Angelis d'Ossat, but the question of the genotype is not discussed. This author describes two species, but Stuckenberg and the older writers are followed, i.e. the forms referred to *Caninia* belong to the group of *C. gigantea*, and closely resemble the *Cyathophyllæ*. Whether *C. gigantea* can properly be retained in *Caninia*, as here re-defined, must depend on a thorough re-examination of that species, but the genus itself, as exemplified by *C. cornucopiæ*, possesses such distinctive characters that, although, in the absence of the present evidence, it was discarded by Milne-Edwards & Haime, de Koninck, Nicholson, and others, it may now fairly be restored.

The nearest genus to *Caninia*, as above emended, seems to be *Campophyllum*, M.-Ed. & H. (type *C. flexuosum*). In this, however, the dissepiments are smaller, more closely set, and form a somewhat broader marginal zone. It is possible that *Campophyllina* must be included in the comprehensive genus *Cyathophyllum*, and a re-examination of the genotype is necessary. In the typical *Cyathophyllæ* the dissepimental zone is much broader than in *Caninia*.

'*Endophyllum*,' M.-Ed. & H., is characterised by the partial or complete discontinuity of the major septa through the dissepimental zone; this feature rarely occurs in *Caninia*.

Stuckenberg's genera *Zaphrentoides* (loc. cit. (1), p. 191 of German text) and *Pseudozaphrentoides* (loc. cit. (2), p. 90 of German text) differ in the rudimentary condition of the primary septa, all of which lie in conspicuous fossulæ (in certain of the species, however, some of the septa considered as primary are probably the youngest of the series).

D'Orbigny selected *Caninia cæru-bovis*, Mich., as the type of his genus *Cyathopsis*; as reasons will presently be given for regarding that species as a fully grown form of *Caninia cornucopiæ*, and as the salient features of both are represented in Dr. Vaughan's subgenus *Amplexi-Zaphrentis*, these groups are consequently here considered as synonymous with the older genus *Caninia*.

Caninia cornucopiæ, Mich. (Plate VI; Figs. 1–4.)

1840. *Caninia cornucopiæ*, Mich.: Congrès de Turin.
— " " " Michelin in Gervais: Dict. d. Sc. Nat., Suppl., 2, p. 185.
1842. *Cyathophyllum imbricatum*, de Koninck: Descr. Anim. Foss. Terr. Carb. Belg., p. 22, pl. C, figs. 5*a*–5*d*.
1842. " " *plicatum*, ibid., p. 22, pl. C, figs. 4*a*–4*c*.
1845. *Caninia cæru-bovis*, Mich.: Icon. Zoophyt., p. 185, pl. 47, fig. 8*d*.
1846. " *cornucopiæ*, ibid., p. 256, pl. 59, fig. 5.
1848. " " Bronn: Index pal., pp. 245 & 368.

[1] In Murch., de Vern., & Keyserl.: "Russia and the Ural Mountains," vol. i, p. 615 (1845).

[2] A. Stuckenberg: (1) Korallen u. Bryoz. d. Steinkohlen. d. Ural. u. Timan.: Mem. Com. Geol., vol. x, liv. 3, St. Petersburg, 1895. (2) Anthoz. u. Bryoz. d. Unter Kohlenkalk v. Central-Russlands: ibid., n.s., liv. 14, 1901.

[3] Angelis d'Ossat, Contrib. v. Brioz. d. Carbonifero [Carnian Alps]: Atti d. R. Acc. d. Lincei, ser. v, mem. ii, p. 256 (1897).

1850. *Amplexus cornu-bovis*, M.-Ed. & H.: Pol. Foss. Terr. Pal., pl. ii, figs. 1–1*b* and 1*c*.
— *Lophophyllum Dumonti*, ibid., p. 350, pl. iii, figs. 3, 3*a*.
— *Cyathopsis cornu-bovis*, A. d'Orb.: Prod. Pal. Univ., t. i, p. 105.
1852. *Amplexus* ,, M.-Ed. & H.: Brit. Foss. Cor., p. 174.
1854. ,, ,, J. Morris: Cat. Brit. Foss., p. 46.
1857. ,, ,, Pictet: Traité d. pal., t. iv, p. 452, pl. 107, figs. 17*a*–17*c*.
— *Lophophyllum Dumonti*, ibid., t. iv, p. 453, pl. 108, fig. 18.
1860. *Lophophyllum* ,, M.-Ed.: Hist. Nat. d. Cor., t. iii, p. 353.
— *Amplexus cornu-bovis*, ibid., p. 349.
1861. *Lophophyllum Dumonti*, de Fromentel: Int. à l'ét pal. foss., p. 290.
1872. *Amplexus ibicinus*, de Kon.: Nouv. Recher. sur. Anim. Foss. d. Terr. Carb. d. l. Belg., p. 67, pl. vi, figs. 2, 2*a*.
— ,, *cornu-arietis*, ibid., p. 72, pl. vi, figs. 4, 4*a*.
— *Zaphrentis cornucopiæ*, ibid., p. 100, pl. x, figs. 5–5*b*, and pl. xv, fig. 2.
— ,, *vermicularis*, ibid., p. 95, pl. x, figs. 1–1*d*.
— ,, *Nystiana*, ibid., p. 103, pl. x, figs. 8–8*a*.
— ,, *Edwardsiana*, ibid., p. 83, pl. vii, figs. 4–4*b*.
— *Lophophyllum* (?) *Dumonti*, ibid., p. 55, pl. iv, figs. 4, 4*a*.

External Characters.

Corallum very variable in shape. When growth is regular (Pl. VI, Fig. 1) the base is strongly curved and conical, the coral becoming more cylindrical as growth proceeds. Most of the examples from Tournai only show the commencement of the cylindrical stage, fully

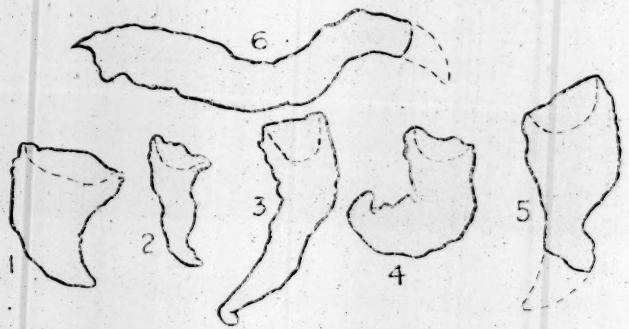


Diagram E.—Outlines of *Canina cornucopiæ*, Mich., showing unusual habits of growth. All half natural size. Tournai. Geol. Survey Coll. Figs. 1–6. R.C. 341–346 respectively.

grown specimens being comparatively rare. Exceptions to such regular growth are frequent; the coral may either expand continuously to its maximum diameter (about 3 cm.) or remain narrow for a considerable length, abruptly expanding and contracting as growth proceeds. Such specimens are often contorted in a remarkable manner; some curious examples are given in outline in Diagram E.

The *epitheca* is of medium thickness, smooth, with numerous fine annular striations; constrictions of growth are frequent, not uncommonly amounting to an interruption in the continuity of the

epitheca. Longitudinal ribbing is practically absent, although faint indications may be occasionally observed.

The *calyx* is deep in young specimens, becoming on the whole shallower with increasing age. The nature and arrangement of the major septa are greatly dependent upon the habit of growth, and age, of the corallum, and since they vary within somewhat broad limits, many names founded on the aspect of the calyx, have been applied to the one species. When growth is perfectly uniform, gradual and successive changes in the development of the septa take place as the coral grows older and more cylindrical. Before considering modifying factors, the history of the calyx, in such regular specimens, may first be detailed.

Commencing with young examples (*'Zaphrentis vermicularis,'* de Kon.), the uniformly thin major septa usually reach the centre of the calyx (often anastomosing in an irregular manner), though some may fall short and join their neighbours; the long counter septum is frequently so connected, and often remains a prominent object until the cylindrical stage is reached, or even throughout growth. In these young examples, the (cardinal) *fossula* is very marked and deep, extending with parallel walls to the centre of the calyx. Minor septa are not yet apparent. From the species founded on such young examples, this may be termed the *vermicularis* phase.

As growth proceeds, the major septa may continue to reach the centre of the calyx for some time, their arrangement becoming very regular (*'Lophophyllum Dumonti,'* M.-Ed. & H., and *Zaphrentis cornucopiæ*, de Koninck, Nouvelles Recherches, pl. x, fig. 5*a*); the counter septum continues prominent, and the rudimentary minor septa make their first appearance. This period may be called the *dumonti* phase. Beyond this the septa begin to fall short and leave a smooth bare tabular area (about 2 mm. in diameter) in the centre of the calyx floor, which forms the inner end of the cardinal fossula (see Pl. VI, Fig. 2). The expansion of the coral now becomes less rapid, the calyx shallows, while the septa retreat further from the centre and the cardinal fossula becomes shorter and rather broader (*'Zaphrentis nystiana,'* de Kon.); this may be called the *nystiana* phase.

A thin ring of dissepiments next appears around the internal margin of the calyx, thinning away near the rim,[1] while the central tabular area now amounts to one-third the diameter of the calyx (*'Zaphrentis edwardsiana,'* de Kon., see Pl. VI, Fig. 4). With further growth the coral becomes cylindrical, and only a slight change is manifested in the calyx. The septa, however, may become still shorter, so that the bare tabular area increases up to one-half the diameter of the coral. The cardinal fossula may also shorten and form a marginal, but still distinct, depression of the calyx floor (see Pl. VI, Fig. 1*k*). The dissepiments do not increase in number or

[1] This feature, though not directly referred to by de Koninck, is seen in the type-specimen of his *Zaphrentis edwardsiana*. As the epitheca of that species is of medium thickness, the recognition of the dissepimental margin may be included in the words "épithèque très épaisse," given in his diagnosis.

thickness, and as they rarely reach the rim of the calyx they may at first sight seem to be absent. This may be termed the *cornu-bovis* phase (ex. *Caninia* '*cornu-bovis*,' Mich.), and with it the development of the corallum is completed.

As above noted, the *minor septa* usually arise at the conclusion of the *dumonti* phase, but their appearance may be delayed to a very late stage, and they are sometimes hardly visible. They are best developed in broad, widely expanded specimens (e.g. Diagram E, Fig. 1), but even here they remain rudimentary.

The (cardinal) *fossula*, whose varying characters are referred to in the foregoing paragraphs, typically lies on the convex side of the corallum, but is often laterally disposed.

But, save for the appearance of the dissepimental ring (a feature confined to the mature part of the corallum), none of the phases above described are truly ontogenetic, for, as will now be explained, they are intimately connected with the habits of growth of the corallum.

From an examination of many broken specimens which are devoid of an infilling of foreign matter, and clearly show the internal structures, two factors controlling septal development are found.

First, it is seen that as the coral becomes cylindrical, the septa die away beneath each tabula and are rebuilt upon its upper surface (see Diagram F, Fig. 1, A); i.e. they become amplexoid in character. But the cylindrical habit may be acquired at any period of growth (e.g. Diagram E, Fig. 3), and consequently amplexoid septa, characteristic of the *nystiana* and succeeding phases, may occur at any time. It often happens that examples showing the long septa of the *dumonti* phase are found to have amplexoid septa in their lower portions.

There is, however, a second factor influencing septal development. It will be noticed from the vertical sections (Pl. VI, Figs. 1*b* and 1*c*, and Diagram F, Figs. 2 and 3) that the tabulæ are by no means equidistant, and from this fact one may infer that the growth of the coral varied somewhat in rapidity from time to time. Hence, although septal information was slower in the cylindrical part of the coral as opposed to the conical part, the development of the septa seen in the calyx, and the depth of the latter, are also dependent on the rapidity of growth between the formation of the last tabula and the death of the animal (Diagram F, Fig. 1, B).

The vertical sections (Pl. VI, Fig. 1*b*, and Diag. F, Figs. 2 and 3) also show that the depression of the tabulæ in the cardinal fossula, though usually considerable, is by no means constant in amount. On the whole the depression lessens as the cylindrical habit is assumed, but the sections show that the size of the fossula in the calyx must be by no means a constant feature.

Conversely to the connection of amplexoid septa with a cylindrical habit, it may be expected that specimens showing continuous expansion of the coral should also show the long septa of the *dumonti* phase, even at a relatively late period of growth; this is indeed the case, and is well exemplified in the broad form of the coral (Diag. E,

Fig. 1) where such septa may be found even when the dissepimental zone, marking a mature stage of growth, is well established.

The foregoing paragraphs are intended to demonstrate that the development of the septa in the calyx is not of specific value in this species, but is largely dependent on two factors, whose relative importance must be expected to vary in different specimens. There remain, however, other data amply sufficient for a recognition of the species, and these will be noticed after describing the internal characters.

Average dimensions.

Height of fully grown adult, at least 6 cm. (a considerably greater length is sometimes attained; see Diag. E, Fig. 6). Diameter of rim of adult calyx, 1·5 to 2 cm. Number of major septa to above diameters, 32 to 33 respectively. (Diameters of 2·5 to 2·8 cm., with 37 septa, are occasionally reached.)

INTERNAL CHARACTERS.

(a) *Horizontal sections.*

1. *Nature of the septa.*—The *major septa* are very thin; their inner ends taper to a fine point and are often curiously twisted; there is, however, occasionally a slight thickening at the inner end of the long counter septum. The cardinal septum dwindles in length at an early stage, and soon becomes very short.

2. *Grouping of the septa.*—There is usually a slight, but distinct, curvature, concave to the cardinal fossula. In the lower, conical part of the corallum, the septa are much thickened by a deposit of stereoplasma, which at first affects them all, but as growth proceeds this becomes restricted to those septa in the two cardinal quadrants, and finally dies away altogether. The deposit characterises the *vermicularis* and *dumonti* phases (i.e. in which septa continuously reach the centre of the coral) and transverse sections of such parts compare well with each other (Pl. VI, Figs. 1*b* to 1*d* and Figs. 2*a* to 2*d*). But when the septa become amplexoid, it will be seen from Diag. F, Fig. 1, that the length of the septa in transverse sections largely depends on the relation of the section to the nearest tabula, for a section may show either very short or very long septa, according as it is cut immediately underneath, or immediately above, one of the tabulæ.

It will be apparent also that a section cut between well-separated tabulæ will usually show longer septa than one cut between closely set tabulæ (Diag. F, Fig. 1, B).

Since amplexoid septa may appear at any stage, transverse sections of this coral should be judged relatively, the appearance of a section being independent of the diameter. Thus, in a broad, rapidly expanding form of the coral (Diag. E, Fig. 1) sections illustrating the *dumonti* phase may be twice the original size of the enlarged figures on Pl. VI, Figs. 2*a* to 2*d*, and contain many more septa; conversely, with forms acquiring the cylindrical habit at an early stage, sections in the *dumonti* phase may appear when but few septa are developed.

3. The (cardinal) *fossula* has no continuous wall (as in *Zaphrentis koninckii*, q.v.). The bounding septa are often unconnected, and the inner end is not closed by septa, but by the intersection of a tabula in the plane of section. In sections across the amplexoid part of the coral the size of the fossula varies considerably, according as the section is cut across the top or bottom of the tabular depression.

4. The rudimentary *minor septa*, appearing in the more mature part of the coral, never transgress the delicate dissepimental ring there found. Where they seem to do so, it will be found that the supposed 'inner wall' of dissepiments is in reality the epitheca repeated by rejuvenescence. One, or two, rings of dissepiments are seen in average specimens; in unusually broad examples, however, three or even four rings may be present, but such cases are rare.

(b) *Vertical Sections.*

Pl. VI, Figs. 1*h* and 1*i*, and Diag. F, Figs. 2 and 3.

These show that the tabulæ are arranged in a fairly regular manner, varying from ·5 to 2 mm., but on the whole about 1 mm. apart. They are dome-shaped in the lower or conical part of the coral, but become flattened in the cylindrical portions. Their depression into the cardinal fossula is at first very marked,[1] but lessens somewhat in the cylindrical portions (Pl. VI, Fig. 1*h*, and Diag. F, Figs. 2 and 3). The tabulæ do not extend through the thin marginal zone of dissepiments developed in the adult stages of growth. These dissepiments have an elongated outline, and are directed upwards and outwards at a very steep angle. They are usually thin and delicate, there being rarely more than two rows of them. They appear to be additional structures, and in no way caused by a "splitting of the wall."

Summary.

There are several constants of value in the determination of this species. They are:—(1) The epitheeal characters; (2) the spacing of the major septa (i.e. their number in a given diameter); (3) the thickening of stereoplasma in the lower and conical part; (4) the characters of the *dumonti* phase (Pl. VI, Figs. 1*b*–1*d* and 2*a*–2*d*); (5) the nature of the dissepiments, and their restriction to the mature growth stages; (6) the nature of the tabulæ. Of these, (2), (4), and (6) are of particular importance.

Localities (both from Dr. Vaughan).

Tournaisian (subzone γ): Burrington Coombe (Mendips); Frome (lowest exposure in the Vallis Vale sequence of quarries).

[1] In many vertical sections cut down the cardinal fossula, some of the tabulæ, while strongly depressed, are seen to bend upwards before reaching the wall. This is due to the fact that the fossular depression, instead of lying wholly in the plane of section, enters it obliquely at those points, and at some distance from the wall. Such an appearance will always be noticed if the coral be twisted so that a straight plane of section cannot always pass down the centre of the fossula.

Remarks.

The synonymy given is a long one, but it should be remembered that the species concerned were founded in days when modern methods of investigation were lacking, and when calicinal characters, so strikingly variable in this species, had to be largely depended upon.

The conclusions above set forth were not reached without a detailed investigation of the abundant material at hand. Several hundred specimens of this species, procured from the type locality, Tournai, and mostly in a fine state of preservation, have been examined, besides numerous examples from the Bristol area, kindly communicated by Dr. Vaughan.

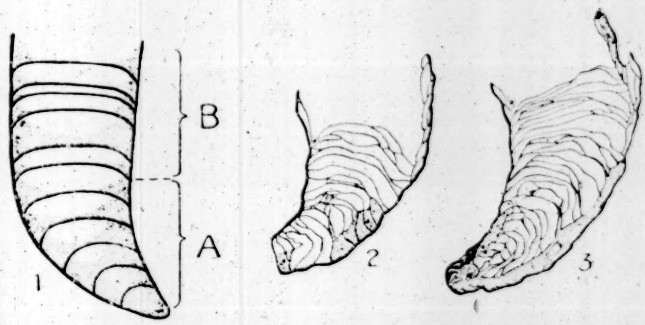


Diagram F.

Fig. 1.—Ideal section illustrating factors governing the appearance of the septa in calices and in transverse sections of *Caninia cornucopiæ*, Mich. Septa shaded. A shows progressive rapidity in retreat of the septa from the tabular surfaces as the coral becomes more cylindrical. B shows development of septa influenced by distance between tabulæ (i.e. by variable rate of growth).

Figs. 2 and 3.—Vertical sections cut down the middle of the cardinal fossula (right-hand side of figures), showing depression of tabulæ into the fossula and appearance of marginal dissepiments in mature growth stages. Epitheca repeated by rejuvenescence at top of Fig. 3. Tournai.

Fig. 2.—Brit. Mus. Nat. Hist. R. 11,689. Fig. 3.—Geol. Surv. R.C. 349. Both natural size.

The synonymy, lengthy as it is, might, with some justification, have been further extended. It is, however, very desirable, not only for zonal purposes, but on general palæontological grounds, that the limits of specific determination should be defined as clearly as possible. A common standard in such matters is not perhaps attainable, but it is believed that a re-examination of the material will confirm the assignation of such apparently diverse forms to the one species.

A suite of specimens, in various stages of growth, and in an exceptionally fine state of preservation, is preserved at the British Museum, while a more complete assemblage is in the possession of the Geological Survey. Both collections were derived from Tournai.

Although this is the only species originally associated with the genus *Caninia*, no figure or description accompanies the first appearance of the name.[1] The paragraph concerned (for which I am indebted to Mr. W. D. Lang) runs as follows:—

"Le genre *Caninia* de M. Michelin, Congrès de Turin, 1840, est du groupe des caryophyllies unistellées ou isolées. Ses caractères sont: polypier pierreux, libre ou fixé, subturbiné, simple, cylindrique, formé de cellules superposées (chaque cellule garnie marginalement de lamelles, quelquefois très courtes et sinueuses" [quelquefois], "atteignant le centre, mais remarquable en ce qu'il est décomposable en petits conoïdes, représentant sans doute la succession des principales phases vitales du polype, et s'emboîtant les uns dans les autres en dehors et en avant de l'axe central; l'extérieur est strié.

"*C. cornu-copiæ*, Mich. Espèce type de ce genre dédié au prince Ch. Bonaparte; elle n'a encore été rencontrée que dans des terrains de formation secondaire, à Sablé (Sarthe), en Belgique, etc. Il en a été donné une figure dans notre Atlas,[2] ses caractères le rapprochent des *Amplexus*, Sowerby."

One of the localities (Sablé) seems to be wrongly given, since it does not accompany the fuller description of the species given later on by Michelin.

I have inserted the word 'quelquefois' in the above description, since it appears to be required to make the paragraph intelligible.

Two years later, de Koninck (Description des Animaux Fossiles, etc., p. 22) described the coral under the name *Cyathophyllum mitratum* (Schlot.), remarking that the exterior is very smooth compared with that of the majority of other species; by an extraordinary mistake, afterwards rectified by him, he at that time included *Cyathaxonia cornu* as a young form of the species. The accompanying figures are poor, though one of them (pl. C, fig. 5*c*) gives a good idea of the tabulæ seen in a broken specimen.

Michelin's first description of his type species appeared in 1846 (Iconographie, p. 256). His diagnosis is generalized, but he noticed that the fossula is deep and prolonged to the centre, and that the coral, on being broken open, shows an almost complete succession of "fissures infundibuliformes s'emboîtant les unes dans les autres" (this is very commonly found in examples from his locality, Tournai). At the same time (loc. cit., p. 185) he described another species, *C. cornu-bovis*, and refers to a figure of this new species having been prepared for, but not published in, the Supplement to the Dictionnaire des Sciences Naturelles for 1840. References to p. 485 of the Supplement are given under the descriptions of both *Caninia cornucopiæ* and *C. cornu-bovis* (although in reality the first mention of the latter appears in the Iconographie). In the latter case, the words "pour le genre" are added: this may mean either that one should look to the Supplement for a description of the genus (which is not given in the Iconographie), or that the generic description in the Supplement should be regarded as a specific description of *C. cornu-bovis*. But these are only matters for surmise, and since *Caninia cornu-bovis* is only the adult form of *C. cornucopiæ*, and as *C. cornucopiæ* was the

[1] Michelin in P. Gervais: article on *Astræa*, Dict. Sci. Nat., Suppl., I, p. 485 (1840).

[2] No figure is given in the Atlas, however: this point will be referred to immediately when discussing Michelin's diagnosis of *C. cornu-bovis*.

only species originally associated with the genus *Cainia*, and was then definitely given as the type (a statement never withdrawn by Michelin), in my opinion it must continue to be so regarded, and the name *cornu-bovis* abandoned.

While the description and figures in the Iconographie leave much to be desired (the best figure is that of *C. cornu-bovis*; pl. 47, fig. 8*a*, where the dissepiments are clearly indicated), Michelin made two observations of great value to later workers in recognising his species; he noted that specimens were in de Koninck's collection as well as in those of Vanderdecke, de Verneuil, and himself, while he also quotes certain of de Koninck's figures[1] of *Cyathophyllum mitratum* as examples of *Cainia cornucopiæ*, and further the only locality given is Tournai, where he remarked that the species were very abundant. Accordingly, when de Koninck redescribed the species many years later, he was able to give a much fuller diagnosis than might have been expected.

As de Koninck's final description was taken from specimens quoted by Michelin himself, it may be accepted with some confidence, and the present diagnosis of the species is primarily compiled from corals compared with de Koninck's figured specimens, and also from the latter's final description ("Nouvelles Recherches," p. 100) given below:—

"Polypier de taille médiocre, en forme de cône allongé assez fortement recourbé, finement pédicellé, à bourrelets d'accroissement peu marqués et à épithèque mince. Calice circulaire à bords amincis et assez profond; trente à trente-deux cloisons principales bien développées, assez fortes, surtout vers leur partie supérieure, mais ne s'étendant pas jusqu'au centre où se trouve un petit plancher fisse d'environ 2 millimètres de diamètre. La plupart des cloisons sont droites, il n'y a que celles qui sont le plus rapprochées de la fossette septale qui s'infléchissent un peu avant de se rejoindre; elles alternent avec le même nombre de cloisons rudimentaires peu apparentes. La fossette septale, qui est assez grande et profonde, s'étend du centre du calice jusqu'à la muraille: elle est située du côté de la grande courbure. Hauteur, 4 à 5 centimètres, diamètre et profondeur du calice, 1, 5 à 2 centimètres."

While this diagnosis in reality only refers to one phase of the coral's growth, this phase is by far the commonest at Tournai, and there can be no reasonable doubt as to its coincidence with Michelin's own conception of the species, described by him as being so abundant at this locality. The sections and calyx figured on Pl. VI, Figs. 2–2*d*, are from this common phase of the coral.

Of the rich assemblage of corals found at Tournai, this species is, as its author noted, remarkable for the ease with which it can be broken open to show the tabulæ within, and their deep depression into the cardinal fossula. While this character cannot now be given the importance assigned to it by Michelin, it has a certain value in recognising his species, since amongst the common corals of Tournai only *Amplexus coralloides* and *Cainia gigantea* have this property, and it is easy to see from Michelin's text and figures that neither of these are referred to under *Cainia cornucopiæ*.

De Koninck ("Nouvelles Recherches," p. 67) regarded *C. cornu-bovis* as a synonym of *Cainia ibicina* (Fisch. d. Wald.). Enquiries kindly instituted by Professor Yakowlew of St. Petersburg and Professor

[1] Descr. Anim. Foss., pl. C, figs. 5*a* and 5*c*.

Pavlow of Moscow (to whom I wish to return my sincere thanks for the trouble they have taken in the matter) have failed to bring to light the specimen figured by Fischer de Waldheim in his "Oryctographie du Gouvernement de Moscou" (Pl. xxx, fig. 5), but as far as one can see from the figure and description there given, the external area of the original specimen is entirely destroyed, and if this is so it would be impossible to specifically (or probably even generically) identify it; in these circumstances, therefore, while calling attention to de Koninck's opinion, one is compelled to retain Michelin's name for the coral.

De Koninck further included d'Eichwald's *Lophophyllum breviceps* (Lethæa rossica, t. i, p. 527, pl. xxix, fig. 6) as a synonym of *L. dumonti*, M.-Ed. & H. (which, in my opinion, is clearly a young form of *Caninia cornucopiæ*); d'Eichwald's species, however, has not been included here in the synonymy, since his figure and description, while certainly leaving the impression that de Koninck was correct in his views, are not sufficiently clear to settle the point without a personal examination of the original specimen, and this for the present I have been unable to carry out. For a similar reason, McCoy's *Cyathopsis cornucopiæ* and *Cyathopsis cornu-bovis* are also excluded from the synonymy, although there can be little doubt from McCoy's description ("Palæozoic Fossils," p. 90), that he was dealing with forms at any rate congeneric with *Caninia cornucopiæ*. One of McCoy's localities for *Cyathopsis cornucopiæ* is given as "Carboniferous shale near Glasgow." This must have been from an Upper Viscan horizon, and it is therefore not probable that a specimen from so high a level was quite identical with the Tournaisian species.[1]

Affinities.

Compared with other Tournaisian corals *Caninia cornucopiæ* is a very distinct species, and amongst such I have not yet noticed any bearing a real resemblance to it. It is true that de Koninck claimed for the species a great similarity with *Zaphrentis delanouei*, but while that may be so for the calices he examined (though the septa are always thinner in *C. cornucopiæ*), the two are completely different in transverse sections (see Plates V and VI) as well as in epithecal characters; the only real similarity occurs in transverse sections across the comparatively rare amplexoid growth stage of *Zaphrentis delanouei*, and in such cases a further section across the lower conical portions will immediately solve the difficulty.

Amplexus spinosus, de Kon., differs in epithecal characters, in the possession of an extremely shallow and ill-marked cardinal fossula, and in the absence of a *dumonti* phase.

Caninia gigantea, Mich., is far larger, has more closely set septa, and the marginal zone of dissepiments is thick, and is developed at an early stage of growth.

[1] McCoy noted in his description of *Cyathopsis cornucopiæ* that "the absence of the vesicular zone of the true *Caninia* is not a little remarkable." This, of course, was because he erroneously took the true *Caninia* to be *C. gigantea*, and was unaware that *Caninia cornucopiæ* developed a dissepimental margin in its final growth stages.

Amplexus coralloides, Sow., differs in the possession of a very inconspicuous cardinal fossula, no dissepimental margin, and an absence of a *dumonti* phase.

Amplexus cornuformis, Ludw., may present resemblances in transverse section, but the tabulæ (if de Koninck is correct in assigning to *Amplexus cornuformis* the tabular sections given on pl. ii, figs. 1*c* and 1*d*, of Milne-Edwards & Haime's "Polypes Fossiles") are more irregular and vesicular than in *Caninia cornucopiæ*.

Corals, as yet undescribed, of a very similar nature to *Caninia cornucopiæ*, are found in the Visean, and many of these are certainly congeneric. Through the kindness of Mr. Sibly, I have been able to examine several of these from the shales overlying the Derbyshire Limestone. But none of them seem quite identical with Michelin's species, and the majority show well-developed minor septa, and, as far as one can judge from transverse sections, they appear to have highly vesicular tabulæ. Other closely related forms are also present in the Visean of the South-West Province, and concerning these Dr. Vaughan has kindly drawn up the following notes, where the differences from typical examples of *C. cornucopiæ* are clearly set forth.

"*Caninia* aff. *cornucopiæ*, mut. $D_{2\ 3}$, agrees very closely with the Tournaisian species.

"The following differences are, however, constant in the specimens which I have specially studied, i.e., of the Tournaisian species from N. Mendips and Stackpole Quarry (Pembroke) and of the Visean mutation from Oystermouth (Gower) and the Hodder:—

"The Tournaisian species is curved almost throughout its length, whereas the Visean mutation adopts a cylindrical habit at an early stage. Apparently connected with this habit of growth is the persistence of the thin vesicular jacket throughout the cylindrical stage of the $D_{2\ 3}$ mutation and its very brief development in the Z. C species.

"The most striking differences seen in a comparison of a set of serial slices are (1) the deep siphuncular depression of the tabulæ in the case of the Tournaisian form, and the broad, relatively shallow depression in the case of the Visean mutation; the lower form may therefore be stated to have a Caninoid and the upper a Campophyllid type of fossula. (2) The greater abundance of tabular intersections between the septa in a horizontal section of the upper form, pointing to the closer approximation of the tabulæ, a fact which is confirmed directly by comparing vertical sections."

Another mutational form is locally extremely abundant in Scotland, on the horizon of the Middle Skateraw Limestone, especially in the shales overlying that limestone in the East Barns Quarry near Dunbar.

This form differs from the Tournaisian species in having more widely spaced septa, and, like the mutation described above by Dr. Vaughan, a comparatively slight depression of the tabulæ into the cardinal fossula, but in other respects the resemblance is extremely close. It is interesting to note that the remarkable variation in habits of growth, seen in the Tournaisian species, also occurs here. The simple conical form is by far the commonest, as it is with the original species at Tournai and in the Bristol area.

The occurrence is, however, strictly local, and I am not yet aware of such corals in other parts of Scotland, though McCoy, as previously noted, records an apparently similar form from "Carboniferous shale near Glasgow."

Distribution.

Little can yet be said concerning the distribution of the species in Britain. The only undoubted examples that have so far come under my notice, have been found by Dr. Vaughan in the South-Western Province. He writes:—

"This species is confined in the South-Western Province to the top of Z and C, that is, it immediately precedes and accompanies the introduction of *Caninia cylindrica*; its maximum lies immediately below the first occurrence of the latter species. In the Gower the species was noted in the Upper Z and γ of the cliff section between Rhossili and the Worm."

One or two fragments, possibly belonging to this species, have been found by Dr. Matley in the Rush Slates of co. Dublin (locality R 6*b*), but they are not specifically determinable.

Although the chief object of this paper has been a revision of the species concerned, some aspects of the question of the zonal value of such fossils, may be briefly noticed in conclusion.

The usual habitat of these corals seems to have been a calcareous mud. They commonly swarm in limey shales, but are comparatively rare in, if not absent from, massive limestones. But no rule to this effect can be given, and in Scotland, certainly, small rugose corals of this type are noticeably local in their distribution. In a bed whose position is accurately known over a wide area, they appear and disappear in a remarkable manner, as if they were very sensitive to conditions of deposit and food supply.

That they may be of the highest stratigraphical value over an area where such conditions seem to have been constant, is not for a moment to be disputed; Dr. Vaughan's admirable work in the South-Western Province supplies an excellent instance. But, as a rule, in correlating over areas exhibiting lithological variation, the relative abundance or scarcity of such corals is of no great value. More trustworthy results should be attained if some of these forms can be clearly proved to have undergone some definite evolutionary change with the passage of time, but until this can be done it would be safer to regard them as untrustworthy for zonal purposes.

The particular corals dealt with in the foregoing articles are of a somewhat simple type, and their structure can hardly be expected to admit of considerable modification. Nevertheless, there is some evidence that an evolutionary change did take place, and that it is, in a general way, helpful to the stratigrapher. It is also always possible that aberrant types may be found of narrow vertical range, though in view of the local occurrence of these corals, evidence apparently pointing to such a fact should be received with caution.

Now that zonal work in the Lower Carboniferous rocks is being actively prosecuted in many areas in Britain, it may be expected that

in a few years much light will be thrown on these problems, of such interest to geologists in general.

I wish to thank Dr. Kitchin and Dr. Thomas for valuable help during the preparation of this article, and also Mr. J. W. Tutcher for the care he has given to those of his photographs appearing in the plates.

EXPLANATION OF PLATE VI.

CANINIA CORNUCOPIÆ, Mich.

FIG. 1.—Fully grown adult of regular form (*C.* '*cornu-bacis*'). Tournai. Geol. Surv. R.C. 331.

FIG. 1*a*.—Key diagram to segments cut from above.

FIGS. 1*b* and 1*e*, 1*d* and 1*e*, 1*f* and 1*g*.—Lower and upper surfaces of segments ii, iii, and iv respectively.

FIG. 1*h*.—Longitudinal section of segment v, cut down the cardinal fossula (right-hand side of figure). Dissepiments partly obscured by intersections of septa (shaded) in the plane of section.

FIG. 1*i*.—Counterpart of 1*h*. Tabulæ outside fossular depression.

FIG. 1*j*.—Lower surface of segment vi, showing ring of dissepiments, and, to right of fossula, a fragment of epitheca repeated by rejuvenescence. (Micro. section.)

FIG. 1*k*.—Calyx (segment vii).

Except the diagram, Fig. 1*a*, all the above are very slightly enlarged ($\times \frac{13}{12}$). 1*b*–1*j* are from camera lucida drawings.[1]

FIG. 2.—Adolescent calyx. The common form at Tournai, representing the original conception of the species (conclusion of *dumonti* phase). Shape of corallum as in lower part of Fig. 1. Tournai. Brit. Mus. Nat. Hist. R. 11,680. $\times \frac{3}{2}$.

FIGS. 2*a*–*d*.—Serial sections below same, showing characters of the *dumonti* phase.[2] $\times 3$.

FIG. 3.—Adolescent calyx (near '*Lophophyllum dumonti*'). Tournai. Brit. Mus. Nat. Hist. R. 11,672. $\times \frac{3}{2}$.

FIG. 4.—Adult calyx ('*Zaphrentis cuvieriana*,' de Kon.). Rim broken down, showing dissepiments round base of calyx. Brit. Mus. Nat. Hist. R. 11,688. $\times \frac{3}{2}$.

Errata.

p. 26 (January Number), line 20 from top of page, for '4*a*' read '4*b*.'

p. 71 (February Number), line 19 from top of page, for 'inner' read 'minor.'

REVIEWS.

I.—ZONES OF THE WHITE CHALK OF THE ENGLISH COAST. By DR. A. W. ROWE. Proc. Geol. Assoc., 1900–1908.

A GEOLOGIST, more confident of his hammer than his pen, friend and rival of Lyell in the establishment of the theory of actual causes, associate of Ami Boué in the foundation of the Geological Society of France, profoundly and permanently influenced the direction

[1] The segments are, of course, opaque, and the septa consequently appear white on a dark ground; in the drawings, however, this colouring is reversed, to secure uniformity with the transparent micro-scopic sections 2*a*–2*d* and 1*j*.

[2] Strictly speaking, only Figs. 2*d* and 1*d* are in the *dumonti* phase. Figs. 2*b*, 2*c*, and 1*b*, 1*c*, being in the *cornucopiæ* phase.

of French geology. Towards the close of his life, in 1849, Constant Prévost let it be known that he had brought to light from his notebooks a work which had lain dormant since 1821 on the geological structure of the cliffs of Normandy.[1] A desire to make it less imperfect, the hope of embracing in its scope the whole coast of France, had allowed him to defer its publication. Before putting the final touches to it he wished to make an appeal to young geologists who had a long future before them, as well as to those who from their position and residence by the coast would be able to make prolonged local researches. But when he died in 1856 his collaborators had not yet appeared, and his descriptions of the Normandy cliffs remained for ever in his notebooks, whilst his geological theories forged ahead and the Geological Society of France, founded by him, developed and flourished. And it is only in our days, after eighty-seven years, that the dream of one of our masters is at last realized in the work that bears the title "The Zones of the White Chalk of the English Coast," a work which has for author A. W. Rowe and for collaborator C. D. Sherborn.

The fact is it is very difficult to study a cliff thoroughly. A cliff shows too much, all at once. It shows so much that it always appears as if one had missed something, and one is always condemned to a sense of incompleteness, whatever care may be taken to rivet the attention, to brace up soft muscles for the climb, or whatever dexterity one may show with the chisel and the pencil.

The English Chalk has, without doubt, been the object of work of high value on the part of members of the Geological Survey, as seen in the works of Whitaker and Strahan and the admirable memoir by Jukes Browne on the Cretaceous rocks; but the best-made maps, the most careful geological surveys, are always at the mercy of a trench, or of a new quarry bringing to light contacts previously invisible. The observer who describes a cliff is protected from these risks; if he allows any fact to pass unnoticed he has only himself to blame; he has not been competent to take the necessary trouble.

For my own part I never stand before a cliff that I have previously studied without making some new observation or noticing something which had formerly escaped me. But to-day the harvesters have passed over the English coast in Rowe and Sherborn, and the work for the gleaner who follows their footsteps will be but small.

Let us rapidly examine the characters of the Chalk cliffs in the different counties studied.

Kent.

Twelve years of observation are condensed into the fine sections of the Kentish cliffs; anyone with the descriptions and sections in his hand can follow the coast and recognize without hesitation the succession of the eight zones of the Chalk and their limitations at any point. The author has brought precision and exactness where

[1] Constant Prévost, "Description géologique du littoral de la France": C.R. Acad. Sci. Paris, vol. xxix, November 26th, 1849, pp. 615-622. The work of C. Prévost, "Sur les falaises de la Manche," had been seen by Cuvier and Brongniart, who reported upon it to the Academy.

formerly had been approximation. He has not confined himself to re-describing the zones with uncertain limits, but with fine analysis he distinguishes a succession of beds which furnish fixed datum-lines —such as the "Bedwell line" in the zone of *Uintacrinus*, the "*Ammonites leptophyllus* bed" (where he mentions 105 examples), the "Sponge bed" forming the base of the *Uintacrinus* zone, the "*Echinocorys pyramidatus* bed," the "*Echinocanus* bed" formed of a carpet of this species, the "Whitaker 3-inch flint-tabular" band towards the top of the *Micraster cor-anguinum* zone, etc. Thus he takes under consideration at the same time the lithological and the palæontological characters; the former, though more easy to recognize at first sight and having the advantage of furnishing at each point geometric limits, but failing from want of permanency from place to place. The author has rendered lasting service in fixing the distances which separate the absolute datum-lines, the limits assigned to his life-zones. Whether the name-fossils chosen for these zones are suitable is open to discussion, as it is well known that the range of few name-fossils are confined to one zone. No one has ever relied upon one fossil for obtaining a zonal determination, and though the name-fossil attains its maximum development in the zone to which its name is applied, we rely more upon a group of associated forms peculiar in certain characteristics or in themselves as our zonal guides. It is this association of life-forms and their variations, as we trace them zone by zone, which gives to zonal geology its value.

Sussex.

The collection of fossils, easy and amusing though it be at certain points of the Chalk cliffs, becomes, unfortunately, exacting at other points where one proposes to base an analysis of the section on their distribution. Thus, in the Beachy Head section the author was forced to rely entirely on the genus *Micraster* for limiting the zones, mapping out the chalk foot by foot, and taking the specimens obtained from each foot of chalk to the water's edge and there cleaning and determining them before proceeding to the next foot. It becomes very difficult to collect this genus of fossils when they are rare or when they are shorn off by the battering action of the shingle at the foot of the cliff, or in those dangerous places where one has to pass hurriedly whilst fragments of cliff are falling from above, or the sea threatens to cut off one's retreat below. The description of Beachy Head gives a fair example of the perseverance of the author in search of his junctions, for there he uses wreckage to increase his reach up the cliff; or that of Seaford Head, where he descends roped at the point where he has noticed the fossils he is in search of by the calcite fracture of their tests, afterwards carefully extracted by the knife from the face of the battered cliff. Hence those geologists who have described the Seaford cliffs before him must not be astonished when comparing their work with his to find it considerably perfected.

Dorset.

The whole of this coast bristles with difficulties, but in spite of altered and consequently barren rocks the author has been able to fix

with varying degrees of accuracy the limits of every zone. The scenery of this boldly sculptured coast is controlled by the influence of the great Isle of Purbeck fault. Inland the beds are horizontal (Wool), and the chalk is so soft that it may be crushed between the finger and thumb; on the coast the beds are folded, broken along the Purbeck fault, and the chalk itself so compacted that it needs to be cut with the chisel. All large fossils are broken, the fragments of the belemnites are often considerably displaced, and the flints shattered into pieces and often drawn out into long dusty lines. Finally, the thickness of the beds themselves is modified, the *cuvieri*- and *Terebratulina*-zones, normally about 134 feet thick where horizontal inland, are reduced to 70 feet on the coast (Durdle).

One of the most remarkable features of this coast is seen at Durdle Cove among slide-planes, where the beds have been pushed northward over one another, ground up into a paste at the junction and re-cemented, thus exposing the *Terebratulina*-zone above and the *planus*-zone below, and the *planus*-zone above and the *Micraster cortestudinarium*-zone below by the cutting back of the cliff by the sea. Notwithstanding the complexity of such inverted succession, the determination of the exposed masses by means of *Micraster* was so definite—the determination being impossible to obtain in any other way—that it speaks highly for the author's method.

Much new information has been given about these complicated sections and poor faunas of Dorset, especially as regards the higher zones. The *Marsupites*-zone yields a fairly rich fauna, and, what is more important, a fauna which closely agrees with that from the same zone on the coast of Kent and Sussex. As regards the belemnites of the higher beds, we note that *Actinocamax quadratus* is limited to a narrow band about the middle of the zone, and *A. granulatus* to the extreme base of the same zone, whilst *Belemnitella mucronata* and *B. lanceolata* are found in profusion from base to top of their zone.

Devon.

If the chalk exposures of Dorset afford views of greater variety and physical features more complicated and remarkable, those of Devon are of special interest on account of the accessibility of the cliffs and the unaltered state of the Chalk. No section on the English coast gives so much detail or tells the story of zonal succession in so convincing or so graphic a manner. It affords a scope for the study of the Echinoidea which would alone render it famous.

Giving a limited exposure from the *cuvieri*- to the *M. cortestudinarium*-zone, it differs from all other sections by the varying zonal measurements. The *Terebratulina*-zone, for instance, varies from 70 to 156 feet in a comparatively short distance, and the *cuvieri*-zone from 0 to 80 feet. Many facts point to littoral conditions, showing that in Devon we get nearer to the western shore of the Cretaceous sea, as we do in the western part of the Paris Basin. Throughout the whole coast there are few lithological characters on which we can rely for more than a quarter of a mile, and this uncertainty applies with equal truth to measurements and to the distribution and variety of the fauna.

There is evidence of erosion along the whole coast as seen in the chalky beds with glauconitic grains, in which is a mingled fauna from Cenomanian deposits and the lower bed of the White Chalk. At Martin Rock the disappearance of the *cuvieri*-zone, etc., on the cliff face affords an example of contemporaneous erosion, the beds having been apparently deposited against a Greensand bank. The *Terebratulina*-sea must have extended further westwards than the previous seas, and that of *Marsupites* still further, for it has left its traces among the flints of the Haldon Hills.

Along this western margin of the Cretaceous sea, in its more littoral conditions, we meet with the lowest occurrences of several White Chalk fossils. Among the most interesting are the Micrasters, as *M. cor-bovis* and *M. leskei* both occur in the *cuvieri*-zone of Devon, that is, lower in the series than in any other exposure in England. *M. cor-testudinarium* appears to have originated in eastern waters, as this group-form is almost entirely absent in the *planus*- and *cor-testudinarium*-zones of the west.

Yorkshire.

The coast of Yorkshire is severe. It is distinguished from all other English sections by the nature of the rock, the peculiar lithology of the beds, the paucity and condition of the fossils, and its physical conformation. There is no counterpart in the south to the grand screes of Speeton, nor are the southern cliffs, however lofty, comparable to the mighty tide-bound ramparts of Bempton.

None but very keen observers would have been able to define around Flamborough Head the limits of the zones, and to fix their boundaries within one or two feet, and the keenness of the authors is clearly shown by the fixing of the zone of *M. cor-testudinarium* below Breil Head, where no man is known to have landed, and where the rocks are so numerous that, even with the smallest sea on, their boat would have been stayed in.

Nowhere do we see the workings of local variation in geographical distribution of fossils more strongly brought out than in this county, and yet we are still able to trace the continuity of life-forms, though in a markedly attenuated degree. The zones of *Rhynchonella cuvieri* and *Terebratulina* are quite in a line with those of southern sections, poor though the fauna is, and it is only when we reach the horizon where *Micraster* usually helps us that the difficulty begins. *M. leskei*, *M. cor-bovis*, *M. cor-testudinarium* were not found, but such Micrasters or fragments of Micraster as were found agreed in all essential features of the test with those in the zones of the more prolific south. The same is seen in the zone of *A. quadratus*, for while the name-fossil is absent, possibly by reason of the thinness of the beds, *Cardiaster pillula*, though notably rare, is found, as usual, at this horizon. The zone of *Marsupites*, though lacking many of its characteristic guide-fossils, exhibits the customary division into *Marsupites*- and *Uintacrinus*-bands.

Further, the vertical range of certain fossils, usually restricted in their distribution, is so vast that their very persistence is bewildering. As instances we quote a range of 800 feet for *Act. granulatus*, and

650 feet for *Act. verus*; while *Cardiaster ananchytis* has been traced for 640 feet and *Infulaster rostratus* for nearly 700 feet outside the limit of their ordinary zones. In point of fact this extension of known ranges for fossils is one of the most conspicuous results of the work in this area.

Isle of Wight.

Whoever visits the Isle of Wight loves to return, but he who has studied its geology cannot leave it. The memoir by Dr. Rowe is fresh proof of this, since after having studied the cliffs of the island he was moved to examine the interior. We owe to this circumstance, and to his association with C. D. Sherborn, a geological map of six inches to the mile, unique of its kind, on which eight zones are defined with precision in a mass of Chalk apparently uniform. These zones show from one extremity to the other of the island variations in thickness, contemporaneity of deposit, and varied faunas, which have furnished information as to the migration of species. The zone of *B. mucronata* shows considerable differences in its thickness, indicative of important pre-Tertiary subaerial denudation.

In this island the Chalk is seen in its greatest thickness and most uniform sedimentation. The principal modification observed is in relation to the mechanical forces which tilted the beds; the Chalk is there hardened, and the flints are crushed as one passes from north to south in proportion to the inclination of the strata.

This memoir is in advance of those of previous writers by reason of the exactness of the stratigraphical observations; it is in advance of the previous memoirs of its author in the revision of the list of fossils, which gives detailed information on zoological groups like sponges, corals, bryozoa, and annelids, which have up to now been neglected.

The mass of the White Chalk, 1,500 feet in thickness, of uniform, slow, placid, and uninterrupted sedimentation, taking place over vast periods of time and over a large extent of country, allows us to follow every stage in unbroken continuity in the evolution of a genus and the equally interesting zonal variations in a species. Studies such as these afford the surest contribution to our knowledge of the evolution of fossil forms. They differ widely from the ordinary systematic papers where so many new species are established on isolated or unsatisfactory specimens, providing so much difficulty and uncertainty in future identification. The author of these memoirs, instead of making new species, has followed the variations of the different typical Micrasters throughout the successive horizons and established series of individual forms, besides distinguishing the mutations in the successive beds from one variety to another of the same specific type.

He has shown that not only is the zonal theory correct, in that at certain levels of the Chalk there exist fossils which are either rigidly restricted to one particular zone (e.g. *Inoceramus labiatus*), or that certain groups of guide-fossils, though not so restricted, are by their association equally characteristic of horizon; but he has also shown that certain fossils vary so markedly in shape or other essential features, as they range from a lower to a higher level, that we can

assign these very shape variations with unerring certainty each to its particular zone.

Another point of interest is the attempt to trace the almost equally instructive variations in horizontal distribution as dependent on the nature of the deposit, the depth, current, and temperature of the Cretaceous sea from Yorkshire to Devon, thereby educing the fact that a fossil which occurs but sporadically in one area may have developed abundantly in another. Regarding other forms like *Kingena lima*, previously recorded only from the lower and upper beds of the White Chalk, Dr. Rowe has filled in the gaps and found that at those levels where it is rarest, in the southern counties it is commonest in Lincolnshire. He has shown the same with regard to *Infulaster rostratus*, which appears earlier in Yorkshire than in the south, with *Cidaris pleracantha*, and with many others.

The work as a whole is stated to be frankly zonal, and therefore zoological; it is, however, of a very high geological standard, enhanced by the accompanying maps and sections drawn on so large a scale by C. D. Sherborn, which show at a glance the position of every zone, every point of interest, every fold of the beds on the coast. The fifty-six fine photographs taken by Dr. H. E. Armstrong, which must have necessitated so many visits and the expenditure of much time and care, succeed in bringing to the eye in a wonderful manner all the critical zonal junctions of importance in the White Chalk of the English coast.

The magnificent White Chalk cliffs of England have at last found interpretation worthy of their grandeur and of their teachings. The work of Dr. Rowe and his associates, C. D. Sherborn and H. E. Armstrong, stands as a model for the future, and as a lasting monument of descriptive geology. CHAS. BARROIS.

II.—Geology of India.

General Report of the Geological Survey of India for 1906, by T. H. Holland, F.R.S., F.G.S., Director. The Mineral Production of India during 1905, by T. D. LaTouche, B.A., F.G.S. Numerous papers on Indian Geology by Officers of the Geological Survey of India.—All the above extracted from the "Records."

(*Concluded from the March Number, page* 126.)

Petrology.

For some time past the attention of the officers of the Indian Survey, including the present Director, has been drawn to a remarkable series of rocks found in the Visagapatam district, and forming a portion of the Eastern Ghauts. By all accounts this region must be a petrologist's paradise: without going too closely into particulars, either petrological or topographical, it may be stated that in this region a great igneous massif with borders of extremely basic rock underlies a development of sillimanite[1] schists, which appear to be

[1] Sillimanite: composition $Al_2O_3SiO_2$, as for andalusite=silica 36·9, alumina 63·1=100.

invariably associated with the underlying complex. The massif thus referred to extends as an ellipse 250 miles long and 60 miles wide in a direction parallel to the adjacent coast of the Bay of Bengal. Together with its covering of metamorphosed sediments it forms a denuded plateau, 3,000 to 4,000 feet in altitude, which is completely carved into hills and valleys. Messrs. Walker & Collins, writing from Canada, and working on rock-specimens obtained by Mr. Middlemiss a few years ago, describe the petrology of this interesting district.

They commence by stating that the suite of specimens appears to represent a metamorphic rock series resulting from various stages of mingling of ultra-basic igneous and of argillaceous sedimentary materials. From a mineralogical point of view their observations are especially interesting, but we may confine our own remarks on the present occasion to the composition and development of the mineral Sapphirine as it occurs in these Visagapatam rocks. Sapphirine, as a mineral species, seems to have been originally recognized by Steenstrup from Fiskernäs in Greenland, and it has been found to occur abundantly in the area now under description. The authors tell us that the true birthplace of this mineral, as evinced by the Indian rock-specimens, is the metamorphic zone of the contact between the 'khondalites' and spinel-bearing magmatic segregations. This Sapphirine-bearing zone is the result of the intermixture of these highly argillaceous schists with segregated spinel rock: the product is rich in alumina, magnesia, and the oxides of iron, but poor in silica; lime is practically absent. Steenstrup's examination of the Sapphirine rocks at Fiskernäs led to the same conclusions.

A comparison of the respective composition of spinel, Sapphirine, and sillimanite indicates the intermediate position that Sapphirine bears to the other two minerals in all its constituents. This is thought to substantiate the view that it is really a product of their interaction. Thus from the pure aluminate of iron and magnesia, viz. spinel, which may be regarded as the utmost limit of a basic species, we arrive at Sapphirine with its 15 per cent. of silica, largely replacing the iron-oxides of spinel, and thence to sillimanite, which is simply a sub-silicate of alumina with a small amount of iron-oxide. It is noteworthy that the amount of alumina is nearly the same in all three minerals, ranging from 65 to a little under 60 per cent. In addition to their notice of Sapphirine the authors describe certain rock-types, containing cordierite, which appear to be new to petrography, whilst a form of pyroxene has been detected having the pleochroism of hypersthene, but with inclined extinction; for this variety the name clino-hypersthene is suggested.

It will be remembered that Mr. Holland in 1901 described the Sivamalai series of Elæolite (nepheline) Syenites and Corundum Syenites of Southern India. On the present occasion we have a note by Mr. Walker on the Nepheline Syenites from the hill-tracts of the Visagapatam district, based on specimens also collected by Mr. Middlemiss. The field relationships of these rocks appear to be those of igneous intrusions, occurring along with other gneissoid igneous types, which form a part of the great boss extending from the Godavari to the Mahanadi, and, as we have already seen, constitute

for 250 miles the northern portion of the Eastern Ghauts. To use the author's words, "this giant eruptive is overlaid in part by metamorphosed sediments, principally khondalite, and to a less extent by laterite."

In describing the typical light-coloured nepheline rock, greenish-brown hornblende, brown biotite and magnetite grains, more or less idiomorphic, occupy only a very small portion of the rock-mass. Anhedra of nepheline and large irregularly rounded grains of felspar constitute the major portion, the amount of nepheline being estimated at 37 per cent. The most interesting constituent, as seen under the microscope, is the felspar, which is really a complex of the ordinary perlitic type; a small quantity, equal to about one per cent., of original calcite also occurs. The bulk analysis of the rock shows 52 per cent. of silica, 26 per cent. of alumina, 3 per cent. of iron-oxides and magnesia, nearly 2 per cent. of lime, and 14 per cent. of soda and potash in equal amounts. An analysis of miaskite from the Urals is given for comparison. The Director remarks that, judging by the previously known associations of this class of rock in South India, Ontario, and Montana, we should be justified in searching for corundum deposits.

There is a further report on the manganese-bearing rocks. The typical rock of this series (intrusive) is composed of potash-felspar, manganese-garnet, and apatite. Its common form when fresh has a texture resembling a medium-grained granite. Mr. Fermor proposes to distinguish this kind of rock as *kodurite*, after the Kodur manganese mine, where it is well exposed. It is further suggested that, as the manganese-garnet is intermediate in composition between spessartite (manganese alumina-garnet) and andradite (lime iron-garnet), the term spessart-andradite might be used, and shortened for convenience into *spandite*. Thus we have a newly-named rock with a newly-named mineral to match.

Economic Geology.

The following remarks are based partly on Mr. Latouche's statement for 1905, and partly on Mr. Holland's Report for 1906.

In the Geological Magazine for July, 1907, we noticed some facts in connection with the "Mines and Minerals of the Indian Empire," based to a certain extent on Mr. Holland's Report for 1903. It can scarcely be expected that any great change has taken place in two years, i.e. from 1903 to 1905. Yet there is an increase in the total value from £4,988,527 in 1903 to £5,707,956 in 1905, and the increase has been steady ever since the beginning of the present century. Gold still heads the list, being nearly double the value of the coal. The greatest leap, however, has been made in petroleum, which has risen from £354,365 in 1903 to £604,263 in 1905—doubtless due to exploitation in Burma; whilst the yield of rubies in that country has fallen from £98,575 to £88,340 within the period. Amongst the various mineral products dealt with the following may be selected for brief notice.

Bauxite.—The more aluminous laterites of India yield in abundance samples which contain nearly 60 per cent. of alumina, with less

than 3 per cent. of silica. As much as 13·76 per cent. of titanium oxides has been found in some samples of bauxite, and as little as 2·70 per cent. of ferric oxide. It is contended that the samples come within the limits of bauxite marketable as a source of aluminium, and in this respect compare favourably with the material now being mined so largely in the South of France. Respecting the development of these Indian bauxites for use as a source of aluminium, the Director appears to favour the notion of the manufacture of pure alumina locally by extraction with alkali, and the export of the pure oxide to aluminium works abroad. He considers that the exploitation of the Indian deposits offers a promising field for private enterprise.

Coal.—There is a considerable yield of coal from beds of Tertiary age in Assam, and mention is made of two fields in connection with the Bengal-Assam Railway, belonging to the same series as those well-known in the Makum field. These coals are said to possess a high average value as fuel, but contain much sulphur and moisture. On the other hand, some of the mines in the Makum field itself are known to have yielded very satisfactory results. As an instance, however, of the minor position held by Tertiary coal in India, it appears that, whilst in 1905 about eight million tons were raised from the Gondwana coalfields, not quite half a million tons were raised from Tertiary beds, and of these latter more than 50 per cent. is produced in Eastern Bengal and Assam. Mr. Latouche states that no coal was extracted in Burma, "the mines in the Shwebo district having been closed, but prospecting for coal is being carried on in the Chindwin district. The result of the examination of the Tertiary coalfields of the Northern Shan States has been disappointing, as the quality of the coal was found to be very poor."

Petroleum.—The production of petroleum remains about the same as before in Assam, where the amount is very small, but has largely increased in Burma, which is now beginning to yield important results. In 1905 the output was again the highest recorded, amounting to over 142 million gallons. The question between the old shallow hand-dug 'twinza' wells and the scientific borings of the several oil companies is naturally a serious one, and Mr. Holland thinks that the native oil industry must soon begin to wane unless the Burmans succeed in finding some means of reaching a greater depth than 400 feet, which at present is their limit. There are several oil-fields, the geological features of some having already been described in the Records. In one case it is shown that the oil-bearing-sands, instead of being continuous over the whole dome, are very limited sandbanks in which the oil is stored. The great variation in thickness, horizontal extent, and levels of each of them points to this, as also does the abundant current-bedding so typical of the strata immediately above. "Perhaps one of the most interesting and puzzling features of this area is the occurrence of the largest quantities of gas, *not* in the centre, where the anticlinal crest reaches a maximum elevation, but at a considerable distance further south; in fact, the field appears to terminate southwards as a gasfield." In another oil-field the effect of a Miocene anticline, lately observed, is brought under discussion.

Gold.—Mysore heads the list in 1905, as heretofore, with a value

of £2,363,457. The other contributions are scarcely worth noticing, except that in 1905 the river dredgings in Burma yielded a value of £2,712, which may be the firstfruits of a paying industry. In consequence of frequent applications for licences to work the alluvial deposits in Upper Burma Mr. J. M. Maclaren was deputed, during the field season of 1905–6, to report on the work in progress on the concessions already granted, and generally on the conditions for alluvial gold-dredging in the rivers of Upper Burma. Mr. Latouche's report on the gold of the Loi-Twang area is not very encouraging. Excluding a small nugget, the value per cube yard in the richest gravel met with was not much more than two grains. The financial aspect of Mr. Maclaren's report is confidential, but we owe to his journey an interesting note and map on "The course of the Upper Irawadi" (*Geographical Journal*, November, 1907) when examining the auriferous alluvial deposits of that and other rivers.

Iron-ores.—The production of iron from its ores in India is still very limited, and according to the statistics supplied by Mr. Latouche the value is even less in 1905 than in 1904, or at least seems to be. Anyhow, the value in 1905 is returned as only £13,827. And yet Mr. Holland announces the discovery of something very like an iron-mountain, whose ores were intended to be used in some future works on the Bengal-Nagpur Railway. The ordinary quartz iron-ore schists of the Dhārwars occur in this locality; but the same schists appear to have been altered locally by intrusive igneous rocks, with the segregation of large bodies of almost pure hæmatite.

Manganese-ore and Mica.—These in point of production more than hold their own. As regards the amount of manganese-ore, this rose from 150,297 tons in 1904 to 253,896 in 1905. The value of this ore Mr. Latouche (p. 57) puts at £82,979, whereas in the table (p. 47) the export value appears to be £248,309. This difference in valuation is so great as to call for some explanation.

W. H. H.

III.—A Summary of the Geology of India. By Ernest W. Vredenburg, A.R.S.M., A.R.C.S., of the Geological Survey of India. Small 8vo; pp. 67, with table of formations. (Calcutta: Thacker, Spink, & Co., 1907.)

THIS is an extremely useful little book, and should be of great service to travellers in India desirous of obtaining a succinct account of the geology of that country in its tripartite division. According to this author the geological formations of India may be classified as follows:—

Recent formations.
Pleistocene.
Siwalik System (Pliocene and Upper Miocene).
Pegu or Mekran System (Lower Miocene and Oligocene).
Eocene.
Mesozoic or Secondary.
Permian and Upper Carboniferous.

Lower Carboniferous and Devonian.
Silurian, Cambrian, and Pre-Cambrian.
Oldest Sediments.
Fundamental Gneiss or Archæan.

In consequence of splitting the Miocene and Carboniferous formations under the above arrangement a word of explanation is necessary. For instance, he observes that there may be no difficulty in deciding whether a particular bed is newer or older than the Middle Miocene, or than the Middle Carboniferous; yet great uncertainty remains, in the first instance, as to whether certain strata in the Siwaliks are to be referred to the Upper Miocene or the Pliocene, and in the second case whether portions of the Lower Gondwana should be referred to the Upper Carboniferous or the Permian. Hence the use of local terms to include a geological group is held to be justified.

The several systems enumerated in the above list are then dealt with in reversed order, commencing with the Archæan so largely developed in peninsular India. He considers the Central Gneiss of the Himálaya to be in part at least of Archæan age. Much has been done of late years in the petrology of this group of rocks. Amongst other matters the author refers to certain enstatite-bearing rocks in the south-east of the peninsula, the types of which most nearly resemble a granite in composition, as having been called 'charnockites' by Holland because the tombstone of Job Charnock, the alleged founder of Calcutta, consists of a slab of that rock.

We could scarcely venture on the present occasion to follow Mr. Vredenburg in his brief but lucid descriptions of the several sedimentary series, whether fossiliferous or the contrary. There is a great amount of useful information conveyed within the scope of a very few pages. A glance at the geological history of India during the period usually known as Permo-Carboniferous (i.e. Upper Carboniferous) must suffice, for this deals with a subject to which special importance is attached.

The author commences by referring to the extensive orogenic upheaval in many parts of the globe at a period which he places towards the end of the Middle Carboniferous. Thus the junction with the Upper Carboniferous is usually indicated by an unconformity-conglomerate, which often exhibits peculiar characters that have been regarded as glacial. After indulging in a certain amount of speculation in connection with this well-marked phenomenon in the history of our planet, he proceeds to deal with (*a*) the Gondwana facies, and (*b*) the Marine facies. We need not in this case follow the author into details of the Gondwana system, but it is interesting to note that in the Himálayan region typical Gondwanas are said to be found in the neighbourhood of Darjeeling and in Bhotán.

There is, however, on p. 40 a statement in connection with the peninsular Gondwanas to which some exception might be taken. "It will be seen," says the author, "that the age of the Coal-measures of India differs considerably from that of the Coal-measures of Great Britain and the *Franco-Belgian* basin, *all of which are Lower or Middle Carboniferous in age*" (the italics are ours). We wonder whence he derives his authority for this statement, since almost any textbook

would tell him that the English Coal-measures, including the Millstone Grit at their base, are of Upper Carboniferous age, nor is there any reason to doubt that the Franco-Belgian coals are practically of the same age. There may be some coals of Lower Carboniferous age in the Scotch measures, but even this is not universally conceded. Moreover, it is not usual to recognize Middle Carboniferous in the European classification. The point does not, of course, affect Indian geology.

The marine facies (*b*) of this group, as it occurs in the Salt Range, Himâlayas, etc., is next dealt with, and the author mentions the discovery of *Gangamopteris* in the Zewan Beds of Kashmir, to which allusion has already been made in the preceding review. Then follows an account of the Indian equivalents of the Triassic, Jurassic, and Lower Cretaceous; this is also in duplicate, viz., (*a*) Gondwana, (*b*) Marine. Next in succession comes the Upper Cretaceous, the Eocene, the Pegu or Mekrân (Flysch) system (Oligocene and Lower Miocene), the Sivalik system, and lastly the Pleistocene (Quaternary Era). A table of geological formations in the Indian Empire completes the work.

W. H. H.

IV.—Geology of the Transvaal.

Transvaal Mines Department. Report of the Geological Survey for 1905. pp. 1–114, 26 plates, and 5 maps. Pretoria, 1906. Price 7*s*. 6*d*.—Report of the Geological Survey for 1906. pp. 1–140, 30 plates, and 7 maps. Pretoria, 1907. Price 7*s*. 6*d*.

Memory chronicles success, but is happily not so mindful of failure. If it were not so ordained few past workers in African stratigraphy, after a perusal of these Reports of the Transvaal Geological Survey, would be able to retain that strong conviction of infallibility so dear to the possessor.

It is scarcely twenty years ago since even the bare outline of the geology of the Transvaal was to all intents unknown. Nowadays our knowledge of the stratigraphy of the country assumes a stable form, and the geological formations stand revealed in something like order. But in the interim between the work of the early pioneers and these, the latest achievements of an organised survey, what a kaleidoscopic view has been presented to the student.

Transvaal stratigraphy, we have read, was of the simplest. It was complex. The Witwatersrand Beds were older than the Pretoria Granites; they were newer: the junction between the two was a faulted one; it was a natural one: the Witwatersrand Beds were Devonian, were Silurian, were Cambrian, were Archæan. Out of chaos came order. If mists still obscure the dawn of the Transvaal rock-succession it is not for the want of effort on the part of the staff of the Transvaal Geological Survey, whose enthusiastic labours have resulted in the discovery of ineradicable landmarks situated toward the region in which the dawn will assuredly break.

The Reports for 1906–7 determine the following rock-succession for the Transvaal, commencing with the newest formations:—

KARROO SYSTEM.

Volcanic Series { Lebombo rhyolites. / Bushveld amygdaloids.
Bushveld Sandstone Series.
Coal-measure Series.
Glacial Conglomerate and Shales.

(Unconformity.)

WATERBERG SYSTEM.

Waterberg Sandstones and Conglomerates.
Felsitic lavas, agglomerates, and shales.

(Unconformity.)

TRANSVAAL SYSTEM.

Pretoria Series.
Dolomite.
Black Reef Series.

(Unconformity.)

VENTERSDORP SYSTEM.

Banket Beds, Klipriversberg and Vaal River Amygdaloids.
Elsburg Series.

(Unconformity.)

WITWATERSRAND SYSTEM.

Upper Witwatersrand Series.
Lower Witwatersrand Series.

(Unconformity.)

Moodies Series.
Crystalline Series.

Between the ancient crystalline series and the Karroo System there are therefore interposed four unconformable, wholly unfossiliferous systems, consisting of limestones, shales, sandstones, and volcanic rocks.

Limitation of space prevents even a mention of the outlines of the many interesting geological features of the districts in which this complicated succession has been so carefully worked out and so clearly described by Mr. Herbert Kynaston (the Director) and by Messrs. Mellor, Hall, Humphrey, and Steart. The readers interested in economic questions rightly receive due attention; while those with a predilection towards physiographical studies are provided with photographs, diagrams, and descriptions of the interesting drainage systems of the Mathlapiesi, Olifants, and Letaba Rivers.

Both Reports, indeed, are albums of excellent photographs of rock scenery, rock-sections, and minerals. The accompanying colour-printed maps are likewise excellent, though it is unfortunate that the colour adopted for the Karroo System should be wholly distinct from that of the published maps of the Cape Geological Commission.

In a new country it is a good sign that the educational value of a geological collection is not lost sight of, and that the museum at Pretoria, under the curatorship of Mr. Tweddill and his assistant Mr. Gandthausen, continues to receive valuable additions. W. G.

V.—Cape of Good Hope, Department of Agriculture.

The Tenth Annual Report of the Geological Commission. 8vo; pp. 296. Cape Town, 1906.

The Eleventh Annual Report of the Geological Commission. 8vo; pp. 176. Cape Town, 1907.

Colour-printed Geological Maps on the scale of 3·8 miles to 1 inch (1 : 238,000):—Sheet 2, Swellendam–Riversdale, 1907; Sheet 4, Malmesbury–Ceres, 1906; Sheet 45, Postmasburg (Griqualand West), 1907; Sheet 46, Barkly West, 1907. Published by the Geological Commission, Cape Town. Price 2*s.* 6*d.* each.

THE Reports embody the results obtained by a vast amount of arduous field-work, often carried on in districts where food and water are scarce, rivers are broad, choked with sand, and fordable only at wide intervals, and where travelling is limited to a short season. Under these hampering conditions it is surprising to find how much solid work has been accomplished. Of the actual extent of the area described we find no precise statement in the Reports, but incidentally we read of the survey of 6,000 square miles by one geologist in one season. To the field-work must be added the preparation of the reports and maps, and the task of seeing them through the press—work apparently accomplished by Mr. A. W. Rogers (the Director) and Mr. A. L. du Toit without clerical assistance. The Survey indeed may be characterised as one yielding a maximum result at a minimum cost.

The Report for 1905 contains an account of the Geology of parts of the divisions of Uitenhage and Alexandria by Mr. Rogers, with a map and 6 diagrams; of the coastal plateau in the divisions of George, Knysna, Uniondale, and Humansdorp, by Mr. E. H. L. Schwarz, with a map and 15 illustrations; of Glen Grey and parts of Queenstown and Wodehouse, including the Indwe area, by Mr. du Toit, with a map and 7 diagrams; of parts of Hay and Prieska, with some notes on Herbert and Barkly West, by Mr. Rogers, with a map and 5 diagrams; of portions of the divisions of Vryburg and Mafeking, by Mr. du Toit, with a map and 4 diagrams; of the Divisions of Tulbagh, Ceres, and Worcester, by Mr. Schwarz, with 16 illustrations on field-work mainly done in 1896; and a short account of a raised beach deposit near Klein Brak River, by Mr. Rogers, with a plan.

The Report for 1906 contains an account of the Geology of parts of Bechuanaland and Griqualand West, by Mr. Rogers, with 12 figures; of the eastern portion of Griqualand West, by Mr. du Toit, with 13 figures.

Among some of the many and interesting results obtained attention may be directed to the discovery by Mr. Rogers of undoubted glacial conglomerates among rocks so ancient as the Griquatown Series; to the occurrence of the Blink Klip Breccia in Hay; and to the account of the diamond pipes of the Kimberley area by Mr. du Toit.

The two Reports deal with almost every formation known in Cape Colony, from the oldest up to the newest. Much work was carried on among the unfossiliferous rocks, older than the Table Mountain Sandstone. The reader is therefore mercifully spared long lists of fossils and of finding old friends under changed names.

Questions of economic interest, such as water supply, minerals of the Knysna District, salt deposits, occurrences of asbestos, etc., are not lost sight of. The Report for 1905 includes a detailed description by Mr. du Toit of the Indwe Coalfield, and is accompanied by a map on a scale of one inch to 1½ miles, showing the outcrops of the Guba and Indwe seams and the position of shafts and boreholes.

On the separately issued colour-printed maps, which maintain the clearness of the earlier issues, the horizontal section at the foot of sheet 45 is a welcome innovation.

Where so much is given it were indeed ungracious to ask for more. In many respects the Reports are books of reference: the reader, therefore, would welcome the free use of headlines and the insertion of page references to the tables of contents which accompany the descriptions of each separately surveyed area. Reference figures and lettering on the diagrams and illustrations would be better if double, and in some cases treble the size, for they are sometimes so minute as to be scarcely legible, even under a hand-lens. Dip-arrows and figures on the black and white maps are also much too small and may easily escape notice. W. G.

VI.—The Pre-Glacial Flora of Britain.

In the Geological Magazine for 1888, p. 567, we reprinted a list of the plants then recorded by Mr. Clement Reid (Ann. of Botany, August, 1888) from the Pre-glacial, Inter-glacial, and Post-glacial deposits of Britain. The Pre-glacial plants were obtained from the Cromer Forest-bed, and the number then enumerated was 58. By his indefatigable labours, especially with regard to plant-seeds, he was enabled to increase the number of species to 78 in 1899, when he published his instructive work on "The Origin of the British Flora." With the aid, meanwhile, of an enthusiastic lady-geologist, his wife, Mr. Reid has almost doubled the number of plant-remains from the Pre-glacial deposits of the Norfolk and Suffolk coasts. No less than 147 are now recorded in a paper "On the Pre-Glacial Flora of Britain," read before the Linnean Society in June, 1907 (Journ. Linn. Soc. Botany, vol. xxxviii. 1908, p. 206). This paper is particularly valuable, not only on account of critical remarks on the species, and on the methods of preserving and identifying the seeds and fruits, but for the series of five photographic plates containing 181 figures of the species. In their concluding remarks Mr. and Mrs. Reid state that the plants "suggest climatic conditions almost identical with those now existing, though slightly warmer."

REPORTS AND PROCEEDINGS.

Geological Society of London.

February 19th, 1908.—Sir Archibald Geikie, K.C.B., D.C.L., Sc.D., Sec. R.S., President, in the Chair.

The following communications were read:—

1. "The Two Earth-Movements of Colonsay." By William Bourke Wright, B.A., F.G.S.[1]

[1] Communicated by permission of the Director of H.M. Geological Survey.

The supposed Torridonian rocks of Colonsay exhibit in their folding and cleavage the effects of two movements analogous in their results to those proved by Mr. Clough in the Cowal district of Argyll. Not only the planes of the first or slaty cleavage, but also the quartz veins formed along them have been folded by the second movement, and may be observed to be crossed at considerable angles by the cleavage produced during this second movement. An extensive series of lamprophyre dykes, obviously later than the first cleavage, are found to be folded and cleaved by the second movement. Moreover, some of these dykes traverse and are chilled against a mass of syenite, which can also be proved to be later than the first cleavage. The distinctness of these two movements is, therefore, considered to be completely established. The second cleavage being of the nature of strain slip, its development along the axial planes of the folds is of interest and is briefly discussed.

2. "Notes on the River Wey." By Henry Bury, M.A., F.L.S., F.G.S.

The part of the River Wey within the Wealden area is divided into six sections: (1) The consequent river cutting the Chalk at Guildford; (2) the subsequent stream coming in from the east at Shalford; (3) the western subsequent stream parallel to the Hog's Back; (4) the continuation of the last westward (the Tilford River), rising at Selborne and receiving many tributaries, including the Headley River, from between Blackdown and Hindhead; (5) the short obsequent section from Farnham to Tilford (the Waverley River); and (6) the portion above Farnham coming from Alton and beyond (the Farnham River). Part 1 deals with the relation of sections 6, 5, and 4 to the Blackwater. It is assumed that there was a consequent river coming down from Hindhead, flowing northwards along the "Waverley River," and joined by the Farnham, Tilford, and Seale rivers. This seems to have been the original head of the Blackwater. But subsequently capture took place by section 3 of the Wey, with the result that the Tilford River passed into the Wey basin, and section 5 was thus beheaded. The development of an obsequent stream near the course of the last eventually tapped the Farnham River, but not the Seale.

Part 2 deals with the Palæolithic Gravels of Farnham. Their height and distribution is discussed, with a view of determining the river which originated the gravels. The ridges constituted by the gravel drop to a lower platform along the Waverley River: this is regarded as the left bank of the consequent valley before that was beheaded. If this were the case, the gravel would have been formed by the Farnham River while still tributary to the Blackwater. At this time, too, probably the Headley tributary drained into the Farnham, and not the Tilford River, giving rise to the south-western portion of Alice Holt.

Part 3 deals with the Farnham branch of the Wey and the Alton district, which is remarkable in that there is a complicated series of Chalk valleys, which spread over some 50 square miles of country and discharge their waters into the Wealden area. One possible

explanation is that this portion originally drained into the Whitewater over the present col of Golden Pot. In discussing this explanation, it appears that the Tisted tributary has the characters of a consequent stream; but there is no very good evidence, except alignment, of the former connexion of the two basins. On the other hand, the Farnham River rather appears to have originated in a Chalk surface than in Wealden beds; and thus it and its tributaries may have been developed on the Chalk portion of the peneplain of the Weald. Thus the Farnham stream appears to present a case of the conversion of a Chalk valley into a Wealden one in its lower part, while in the Caker stream the reverse is the case, and it is the upper part of the stream that has entered Wealden beds.

On April 1st, 1908, at 7·45 p.m., a Special General Meeting will be held, to consider the following resolution, signed by ten Fellows of the Society:—

"That the Council be requested to take the necessary steps, at an early date, in order to allow of the admission of women to full Fellowship of the Geological Society of London."

The following amendments to the foregoing resolution will be proposed and seconded:—

"That it is desirable that women should be admitted as Fellows of the Society, assuming that this can be done under the present charter."

"That a ballot of all the Fellows of the Society resident in the United Kingdom be taken to ascertain whether a majority is in favour of admitting women to the Society, and, if so, whether as Fellows or as Associates."

CORRESPONDENCE.

GLACIATED ERRATICS IN SCILLY.

Sir,—During September, 1907, Professor A. G. Nathorst and I made a flying visit to Scilly in order to see the very interesting deposit with striated erratics discovered by Mr. George Barrow. On St. Martin's Head, the highest point in the Isles, we obtained some additional evidence. When I formerly visited this spot in company with Mr. Barrow we did not succeed in tracing the striated erratics to a greater height than 100 feet above the sea, though we noticed unstriated fragments of a similar buff sandstone at higher levels. During this later visit Professor Nathorst and I worked slowly up the slope leading to the Beacon, turning over the boulders of sandstone half imbedded in the soil. We thus found that though at the higher elevations the exposed surfaces of this rock had all lost their striæ through the action of the weather, yet in every case the surfaces protected by soil were beautifully glaciated. We traced these erratics up and up, till we found an imbedded block at a level less than 20 feet below the highest point, which is marked 160 feet above Ordnance datum.

On returning to London I showed these striated masses of reddish or buff fine-grained sandstone to several of my colleagues, for I could not recognize them as belonging to any Cornish rock. Neither could

my colleagues from South Wales identify them; but Mr. Lamplugh at once recognized them as exactly resembling the Upper Old Red Sandstone of the South of Ireland. This was an unexpected find; but as we know that during the Glacial Epoch glaciers in the South of Ireland descended to the sea-level and thrust long tongues into the Atlantic, there is nothing surprising that the icebergs calving off should drift over to Scilly and there be stranded. CLEMENT REID.

HAMPSTEAD.
February 26th, 1908.

OBITUARY.

EDMUND V. MOJSISOVICS, Sc.D.

BORN OCTOBER 18, 1839. DIED OCTOBER 2, 1907.

JOHANN AUGUST GEORG EDMUND MOJSISOVICS EDLER VON MOJSVAR was born on October 18th, 1839, at Vienna. Matriculating at the University of Vienna in 1858, he there studied jurisprudence, and in 1864 graduated as a Doctor of Laws. While at the University he pursued also geological and geographical studies. An enthusiastic mountaineer, he was, when only 25 years of age, one of the founders of the Austrian Alpine Club, which was formed in 1862. From 1862 to 1865 E. v. Mojsisovics was Secretary of the Club, and in that capacity edited the first volume of their *Mittheilungen*, that appeared in 1863, and the first volume of their *Jahrbuch*, which was issued some two years later. Up to this time E. v. Mojsisovics was an ardent mountaineer, and contributed to the publications of the newly-formed club a number of articles on his mountaineering expeditions.

In 1865 E. v. Mojsisovics joined the Austrian Geological Survey as a volunteer, and during the summer months of that year was occupied in an investigation of the Ortler Alps. But his great physical exertions during these months brought on an affection of the muscles of the legs that not only confined him to his bed during the following winter, but prevented him from again attempting any particularly arduous climbing. Nevertheless, his health was so far restored during the summer of 1866 that in the months of August and September he was able, together with Professor Eduard Suess, to carry out geological investigations in the Salzkammergut. In 1867 Mojsisovics became officially attached to the Survey, being promoted in 1873 to the rank of Chief Geologist, and in 1893 to the position of Vice-Director, a position which he occupied until the year 1900.

In 1871 he married Charlotte Voelcker, the daughter of Georg Voelcker, a London banker.

During his thirty-five years' connection with the Austrian Geological Survey his work was almost exclusively confined to the Alps, at first in the Vorarlberg and the North Tyrol, later in the South Tyrol and the neighbouring parts of Venetia, but more especially in the Salzkammergut and the surrounding districts of Upper Austria, Salzburg, and Upper Steiermark. Only in the year

1879 did he for a time leave his work in the Alps in order to carry out some geological investigations in Bosnia and Croatia.

He retired from the Geological Survey in 1900, and went to reside near Mallnitz, in Carinthia, a village picturesquely situated at a height of about 3,800 feet on the Mallnitzer Tauern, one of the southern extensions of the Hohe Tauern. But his retirement amidst the mountains which he loved so well was not for long, for on the morning of the 2nd of October he succumbed to a most painful affection of the tongue and throat from which he had suffered for some time past.

Notwithstanding the amount of the field-work which Dr. E. v. Mojsisovics had accomplished, he was also a most prolific writer, being the author of some one hundred and fifty works, some, especially his palæontological memoirs, being of considerable size. His first important work seems to have been one "Über die alten Gletscher der Südalpen," that appeared in 1863 in the publications of the Austrian Alpine Club, in which he proposed to substitute for the threefold division of Alps a twofold subdivision into the Western and Eastern Alps as being the more natural one, a view which is now generally adopted. Perhaps one of his most important geological works was that entitled "Die Dolomitriffe von Südtirol und Venetien," which appeared during the year 1878; his researches here showed that these enormous masses of dolomite, the remains of Triassic coral reefs, included the faunas of several distinct Triassic horizons.

Another large work, a geological monograph of the Salzkammergut, unfortunately remains unfinished. Only a short stretch of the geological relationships of this district was contributed by E. v. Mojsisovics to Dr. Diener's work entitled "Bau und Bild der Ostalpen," which appeared in 1903. Of the monograph itself, which was to have appeared under the title "Das Gebirge um Hallstatt," only the palæontological part, bearing the title of "Die Cephalopoden der Hallstätter Kalke," has been published. This, however, is an enormous work; it forms Band vi of the "Abhandlungen der k.k. geologischen Reichsanstalt." The first part, with the sub-title "Die Mollusken-Faunen der Zlambach- und Hallstätter Schichten," but dealing only with the Cephalopoda, was issued in three sections, of which the first (pp. 82; 32 plates) appeared in 1873, the second (pp. 92; 38 plates) in 1875, and the third, forming a supplement (pp. 182; 23 plates), so late as 1902, the whole making a volume of some 356 pages and 93 plates. The second part of "Die Cephalopoden der Hallstätter Kalke" appeared in 1893; it is in two volumes consisting of 835 pages of text and 130 plates, and contains descriptions of more than 700 species. In the meantime, however, E. v. Mojsisovics issued several important works. Thus, in 1882 he published his work on "Die Cephalopoden der Mediterranen Triasprovinz" (Abhandlungen der k.k. geologischen Reichsanstalt, Bd. x), a large volume comprising 322 pages of text and 94 lithographic plates. But E. v. Mojsisovics did not confine his attention to the Triassic fauna of the Alps; in 1886 his memoir on the "Arktische Triasfaunen" (pp. 157; 20 plates) was issued by the Imperial Academy of Sciences

of St. Petersburg, the same Academy publishing some two years later his memoir "Über einige arktische Trias-Ammoniten des nördlichen Sibirien" (pp. 22; 3 plates). In the same year appeared his work "Über einige japanische Trias-Fossilien" (Beiträge zur Paläontologie und Geologie Österreich-Ungarns und des Orients, Bd. vii, pp. 163–178; 4 plates). Having published some preliminary remarks on the Cephalopod faunas of the Himalayan Trias in 1892, his "Beiträge zur Kenntnis der obertriadischen Cephalopoden-Faunen des Himalaya" was published by the Vienna Academy in 1896 (Denkschr. d. kais. Akad. d. Wissensch., math.-naturw. Kl., Bd. lxiii, pp. 575–702; 22 plates), an English translation of the work appearing in 1899 in the *Palæontologia Indica* (series xv, Himalayan Fossils, vol. iii, part 1).

Probably there is no one to whom we are more indebted for our knowledge of the Triassic rocks and of their Cephalopod faunas than to Dr. E. v. Mojsisovics, the zoning of the Triassic rocks being in a very great measure, in fact almost entirely, due to his researches.

He was the recipient of many honours and distinctions, the University of Cambridge conferring upon him in 1881 the degree of Doctor of Science (*honoris causâ*). He was also a member of many learned societies, including the Geological Society of London, of which he was elected a Foreign Member in 1893.

GENERAL SIR RICHARD STRACHEY, R.E., G.C.S.I., LL.D., F.R.S.

Born July 24, 1817. Died February 12, 1908.

This distinguished officer, who was born at Sutton Court, Somerset, was engaged in important military and engineering works in India from 1836 until 1871. The construction of irrigation works, canals, and railways was varied by active military service, Strachey having taken part in the first Sikh war; but while his energies were concentrated mainly on the practical applications of science, he was greatly interested in botany, meteorology, geology, and physical geography. Thus he utilized his opportunities, when engaged in topographical surveys, of making observations on the glaciers of the borders of Tibet and on the geology of the Himalayas; and the results were communicated to the Geological Society and published in vols. vii and x of the Quarterly Journal. He was a member of the Council of the Society during the years 1853–5, and again in 1866–7; and President of the Royal Geographical Society from 1887 to 1889. During the later years of his life General Strachey served at times on the Council of the India Office.

REV. THOMAS WILKINSON NORWOOD, M.A., F.G.S.

Born 1829. Died January 26, 1908.

The Rev. T. W. Norwood, formerly of Cheltenham, and for some years a member of the Cotteswold Naturalists' Club, was appointed Vicar of Wrenbury in Cheshire in 1878. There he remained for twenty-nine years, when he retired to Snaith in Yorkshire, and died January 26th, 1908, at the age of 79. During his residence in

Gloucestershire he formed a large collection of Liassic and Oolitic fossils; among which were many remarkably fine examples of *Hippopodium ponderosum*, *Terebratula simplex*, and *T. plicata*.

We regret to record the death of Dr. H. C. Sorby, F.R.S., Past President of the Geological Society, which occurred at his residence, 6, Beech Hill Road, Sheffield, on Monday, the 9th March, in his 82nd year. We shall write more fully of Mr. Sorby's work in our May Number.

MISCELLANEOUS.

Natural Caverns in Chalk.

In a paper on the Chalk published in the *Rochester Naturalist* (see vol. iii, 1907, pp. 466, etc.) Mr. S. Sills draws attention to the natural chambers or caverns that have occasionally been encountered in well-sinkings or borings in the Chalk. Thus Prestwich mentioned a cavern that was proved in the Chalk at a depth of 270 feet below the surface at Knockholt, near Sevenoaks. It was 30 feet long by 12 feet wide and 18 feet high, with a stream of water running through it.

Beneath the city waterworks at Strood, near Rochester, a natural chamber was discovered in 1879. The cavern was found to be roughly Z-shaped on plan, the stem of the letter lying in the line of a fault from north to south. The upper arm was 28 feet long and 10 feet wide, with a height of from 12 to 17½ feet; it appeared to terminate in a tunnel-shaped fissure. The stem measured 16 feet in length, with a width of 9 to 12½ feet. The lower arm was 18 feet long and from 3 to 10 feet in width, ending in a large fissure which extended from floor to roof.

Later excavations proved the fissure of the upper arm to be much more extensive, and in 1903 it was explored to a distance of 150 feet from the cavern, and was found to be 4 or 5 feet wide and 5 to 6 feet high. The floor was paved with a layer of tabular flint; and the sides were scored, and in many places deeply undercut, by the action of flowing water. The stream would appear to have found its way primarily along the flint floor and, being intercepted by the fault, was diverted to the big fissure where it found exit to the river. The level of the flint layer is about one foot above low-water mark of ordinary tides in the Medway, and the rise of the waters to 17 or 18 feet above this level would pen up the stream until the ebb released the waters. Fine sand and clay washed down, from strata overlying the Chalk, through pipes and fissures, gradually silted up the stream bed. The force of the stream being insufficient to remove this silt, a fresh passage was carved out above it in chalk already softened by the water's action. This process was repeated until the present result was obtained.

It was observed that at various points, where deviations in direction took place, there were enlargements of the passage-like chambers; and that the excavation was both horizontal and vertical, while the roof was drilled deeply, as if by a tool, in many places.